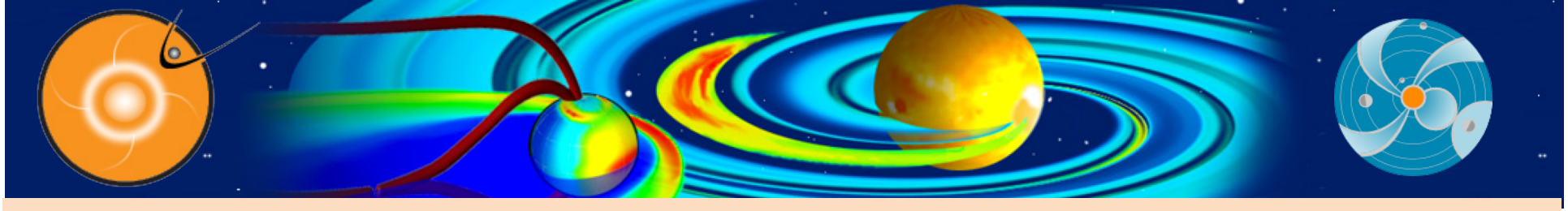


Community Coordinated Modeling Center

CCMC Report 2016-2018

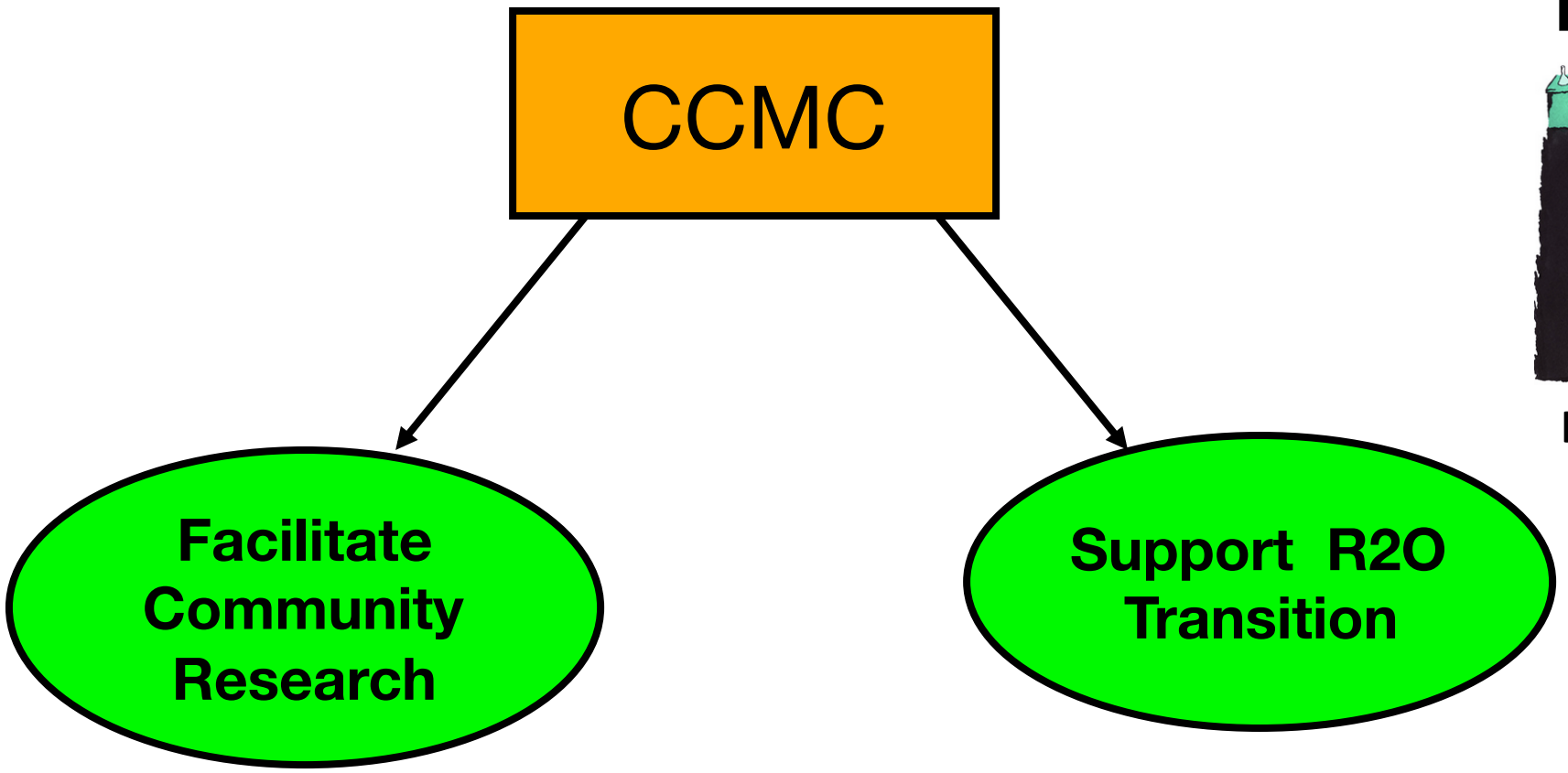
M. Kuznetsova & CCMC Team

MODELS • DATA • TOOLS • DATABASES • SYSTEMS • SERVICES

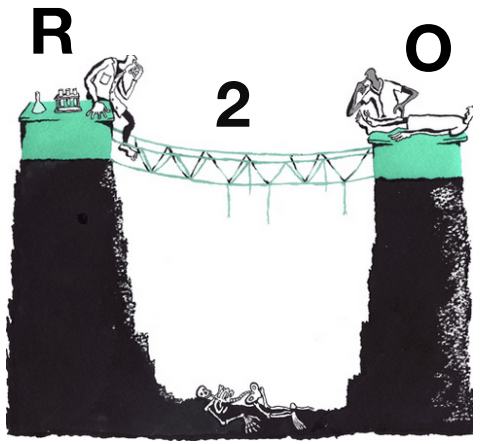
Outline

- Evolving view on CCMC role in space weather capabilities ecosystem
- Updates
  - Model on-boarding
  - Usage statistics
  - Testing and validation
  - Infrastructure and information architecture
  - Visualization
  - Education

CCMC 2002 (original)

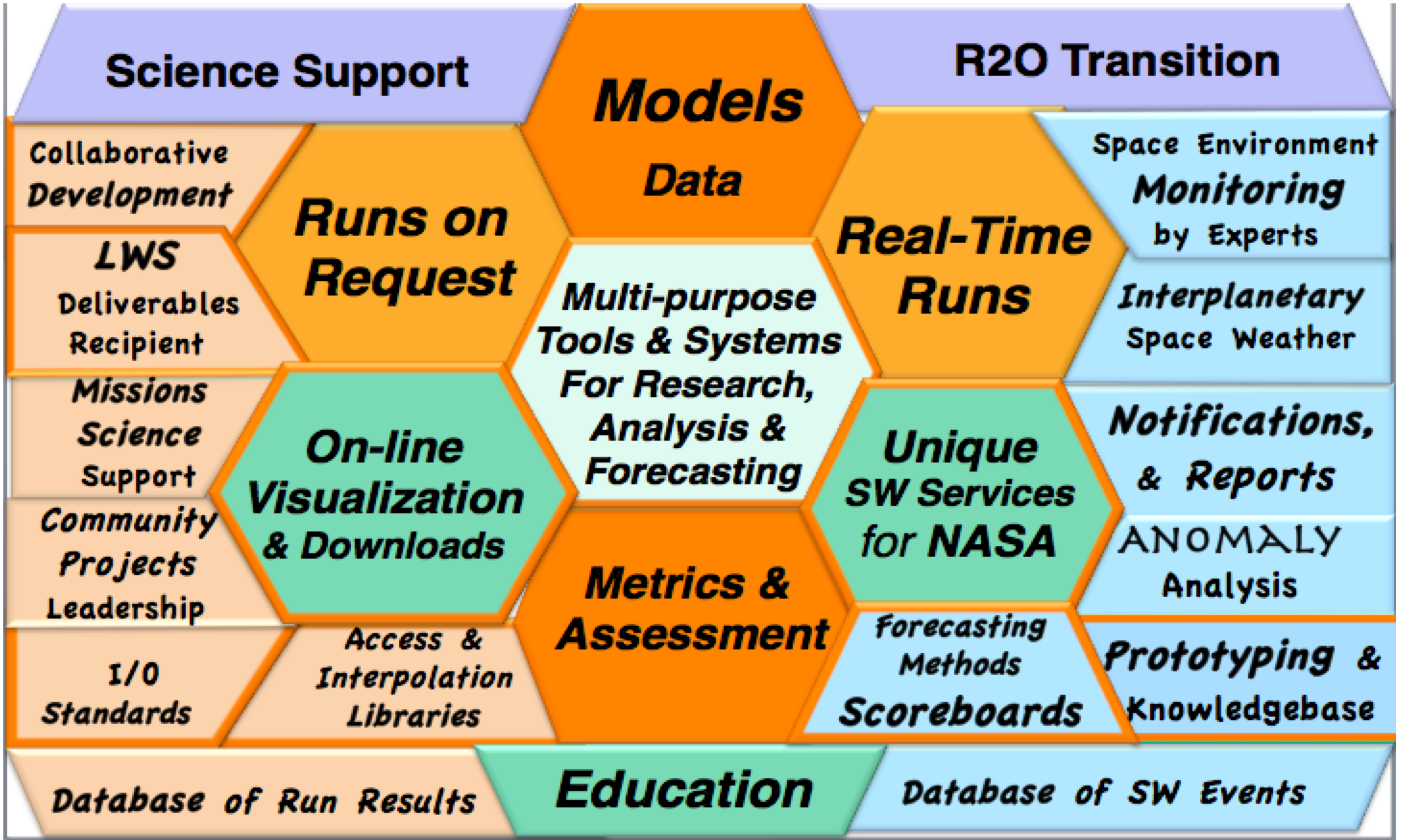


Motivation



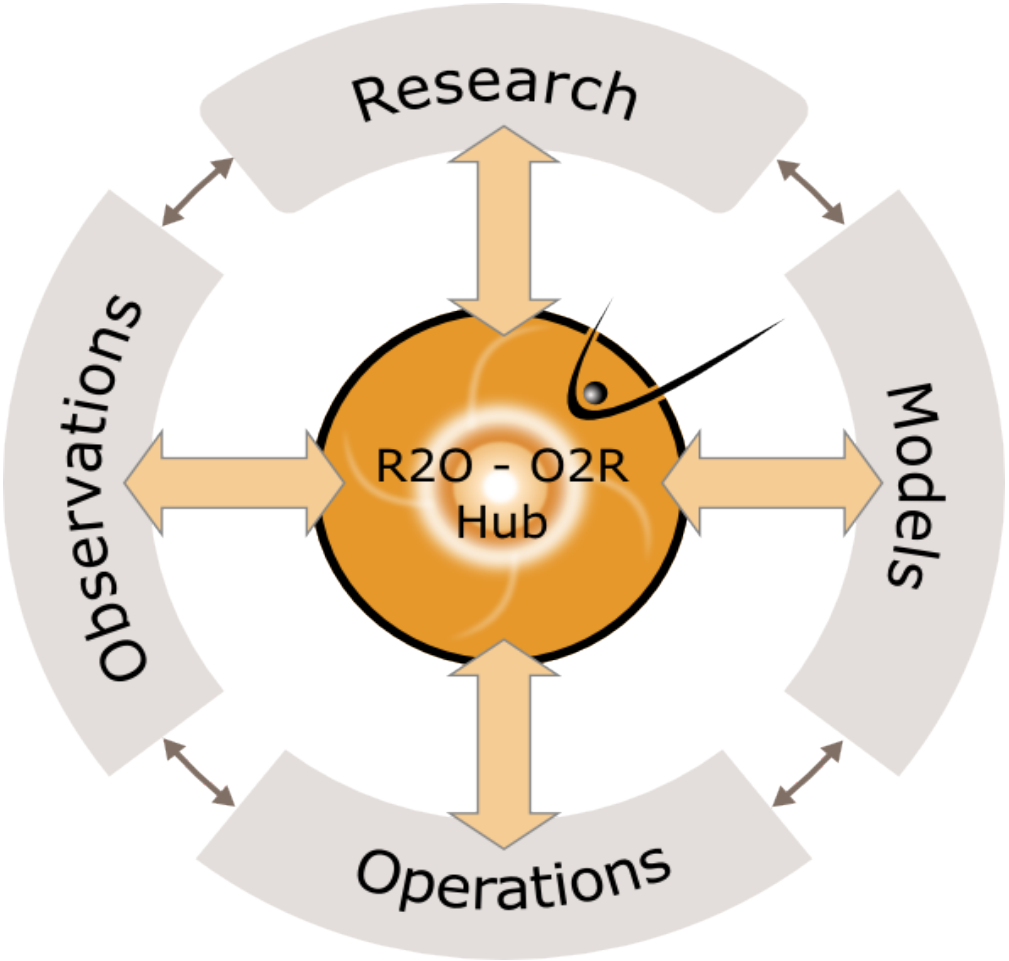
Hard-2-Cross R2O Valley of Death

CCMC 2014 (interconnected activities)

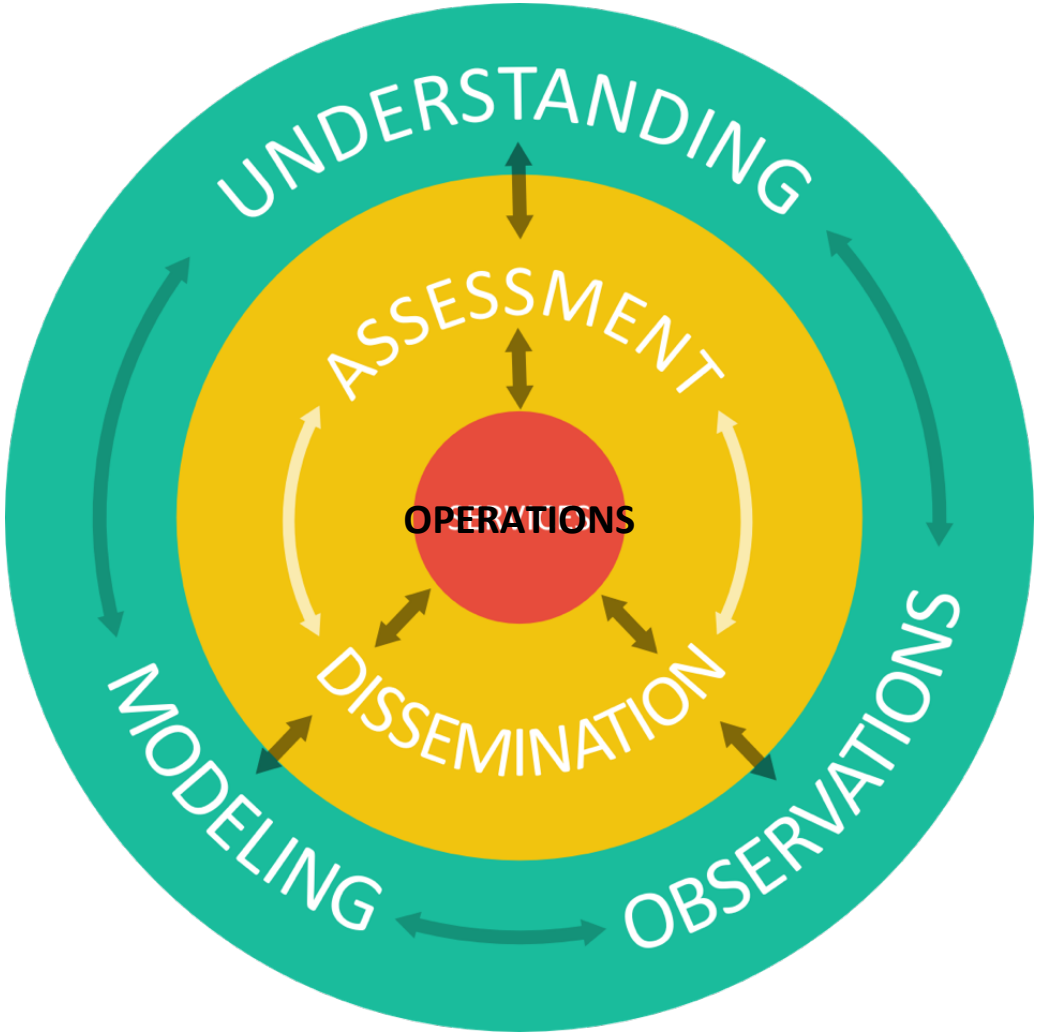


CCMC 2016 (central hub for R2O-O2R)

collaborative development of
space weather predictive capabilities



A Space Weather R20-O2R 'Dartboard'



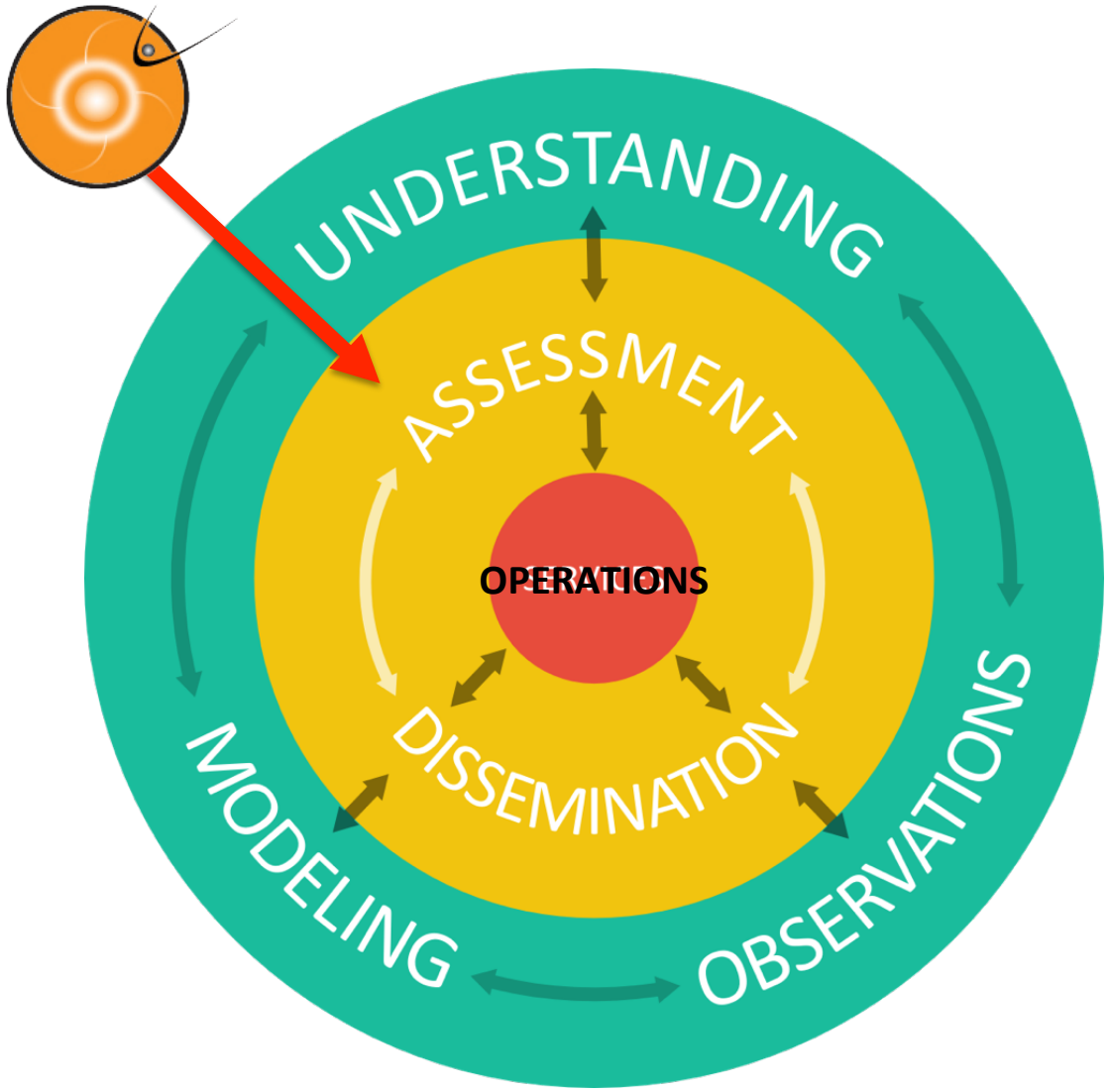
RESEARCH

R2O-O2R Hub

OPERATIONS

interconnects all key elements of space weather capabilities and targets improvement of operations

CCMC 2018: A hub for R2O-O2R



An R20-O2R hub enables closing multiple loops in the space weather capabilities ecosystem

DISSEMINATION & ASSESSMENT are primary CCMC function

RESEARCH | R2O – O2R Hub | OPERATIONS

INGESTION & DISSEMINATION

Ingesting models and data products.

Developing **model input generation tools.**

Building **modular, flexible architecture and procedure** for on-boarding.

Providing **simulation services** (Runs-on-Request, Instant Runs, Real-time runs)

Developing tools for **RoR, IR, RT** results dissemination (web-based visualization & analysis, downloads)

Designing **actionable displays, forecasting and analysis applications.**

Building flexible systems for ingestion and dissemination of **external observation data and simulation output** (historic event and real-time streams).

Building/maintaining interactive archives. Implement standards.

ASSESSMENT

Testing model robustness.

Assessment of model output quality, prediction accuracy and reliability.

Tracking progress against established metrics and benchmarks.

Prototyping of forecasting & analysis techniques for potential transition to operational services.

From CCMC Programmatic Review 2017: highest priority tasks:

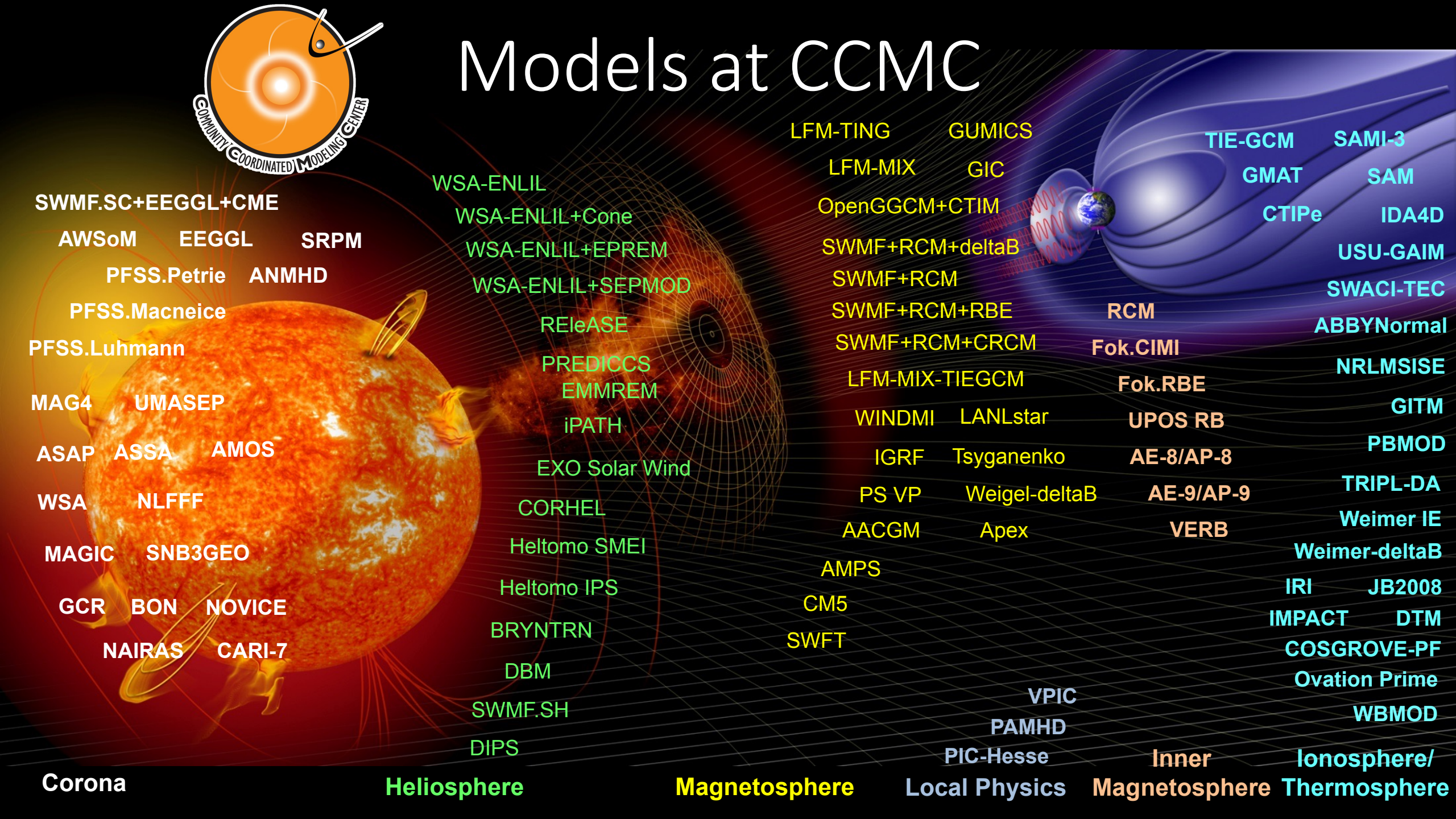
- Hosting and maintaining accessibility to a collection of heliophysics research models and making runs and results available for use by the scientific community and the general public (**dissemination**).

- Testing and validating the hosted models and tools, so that their utility can be evaluated for potential transition to operational organizations (**assessment**).

CCMC Advisory Group 2016 suggestions:

Improve visualization.
Improve management of simulation archives.

Models at CCMC



Corona

- SWMF.SC+EEGGL+CME
- AWSoM
- EEGGL
- SRPM
- PFSS.Petrie
- ANMHD
- PFSS.Macneice
- PFSS.Luhmann
- MAG4
- UMASEP
- ASAP
- ASSA
- AMOS
- WSA
- NLFFF
- MAGIC
- SNB3GEO
- GCR
- BON
- NOVICE
- NAIRAS
- CARI-7

Heliosphere

- WSA-ENLIL
- WSA-ENLIL+Cone
- WSA-ENLIL+EPREM
- WSA-ENLIL+SEPMOD
- REleASE
- PREDICCS
- EMMREM
- iPATH
- EXO Solar Wind
- CORHEL
- Heltomo SMEI
- Heltomo IPS
- BRYNTRN
- DBM
- SWMF.SH
- DIPS

Magnetosphere

- LFM-TING
- GUMICS
- LFM-MIX
- GIC
- OpenGGCM+CTIM
- SWMF+RCM+deltaB
- SWMF+RCM
- SWMF+RCM+RBE
- SWMF+RCM+CRCM
- LFM-MIX-TIEGCM
- WINDMI
- LANLstar
- IGRF
- Tsyganenko
- PS VP
- Weigel-deltaB
- AACGM
- Apex
- AMPS
- CM5
- SWFT

Local Physics

- VPIC
- PAMHD
- PIC-Hesse

Inner Magnetosphere

- RCM
- Fok.CIMI
- Fok.RBE
- UPOS RB
- AE-8/AP-8
- AE-9/AP-9
- VERB

Ionosphere/ Thermosphere

- TIE-GCM
- SAMI-3
- GMAT
- SAM
- CTIPe
- IDA4D
- USU-GAIM
- SWACI-TEC
- ABBYNormal
- NRLMSISE
- GITM
- PBMOD
- TRIPL-DA
- Weimer IE
- Weimer-deltaB
- IRI
- JB2008
- IMPACT
- DTM
- COSGROVE-PF
- Ovation Prime
- WBMOD

Latest Solar/Helio Model Deliveries

- CORHEL (upgrade)
- TDm Flux Rope Designer
- DBM/DBEM
- DIPS (CME Deflection in InterPlanetary Space)
- EPREM
- HelTomo IPS (upgrade)
- iPATH
- MAG-4 (upgrade)
- SEPMOD
- SURF (surface magnetic field convection code)
- SWMF AWSoM-R
- WSA 4+ (upgrade)
- WSA-ENLIL 2.9d (upgrade)

SWMF AWSoM-R

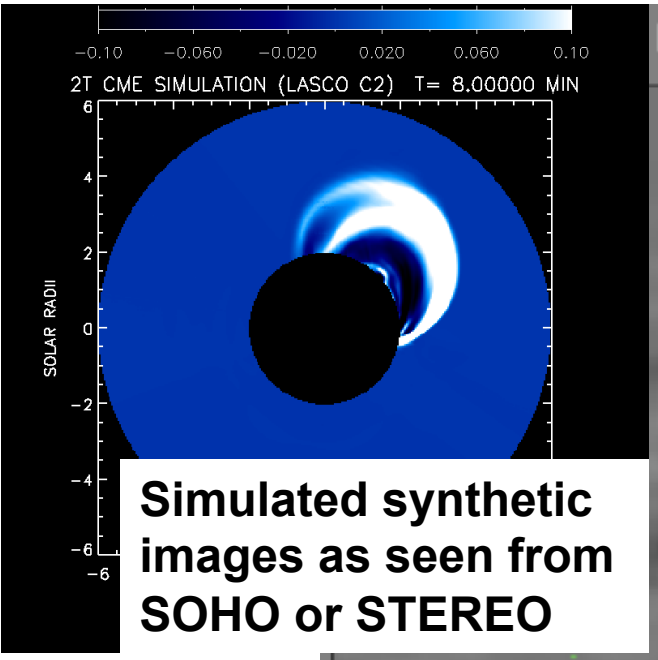
StereoCAT CME Analysis Tool

EEGGL Eruption Event Generator by Gibson & Low
(delivered as a package)

SWMF AWSoM-R

Global MHD simulations of CME plasma and magnetic structure eruption and propagation through space

60+ user simulations executed since Nov 2016



Simulated synthetic images as seen from SOHO or STEREO

Simulated magnetic structure of a CME

SWMF Team: Igor Sokolov, Meng Jin (UMich)

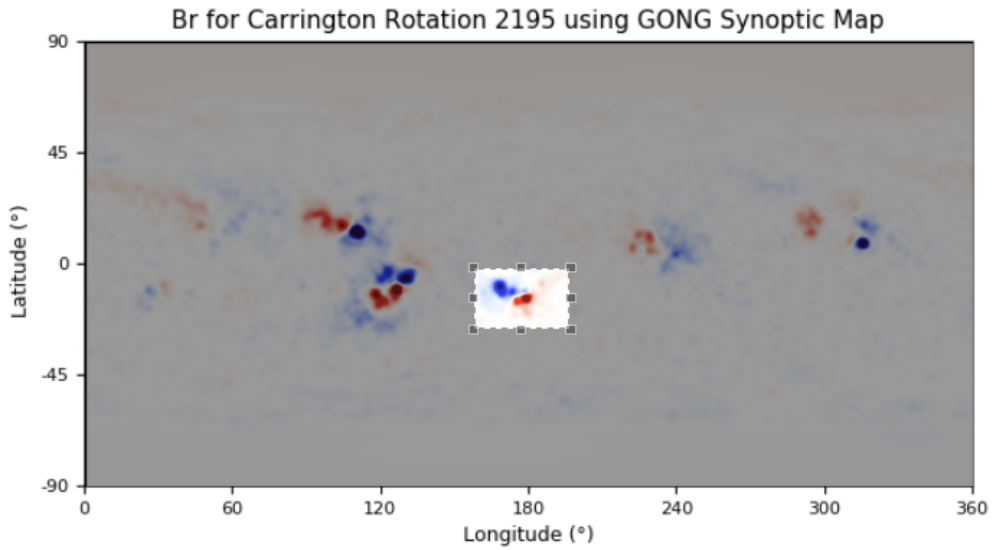
CCMC: R. Mullinix, A. Taktakishvili

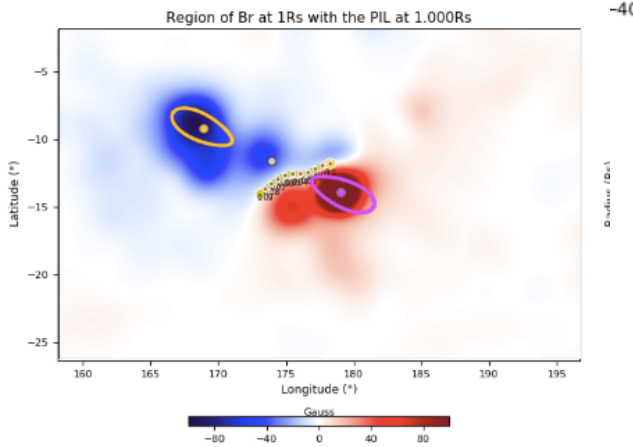
TDm Flux Rope Designer (PSI)

- Run Request Selection
- Magnetic Field Map Selection
- Active Region Selection
- Polarity Inversion Line Selection
- Flux Rope Selection
- Summary

Magnetic field map source

- (•) GONG
- ( ) HMI
- ( ) Kitt Peak
- ( ) MDI
- ( ) Mount Wilson
- ( ) SOLIS
- ( ) Wilcox
- ( ) User

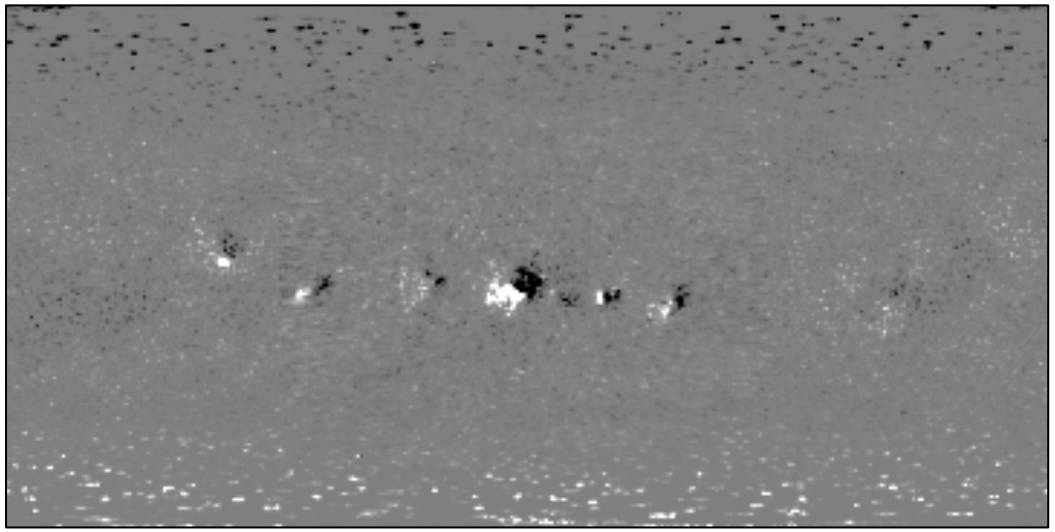


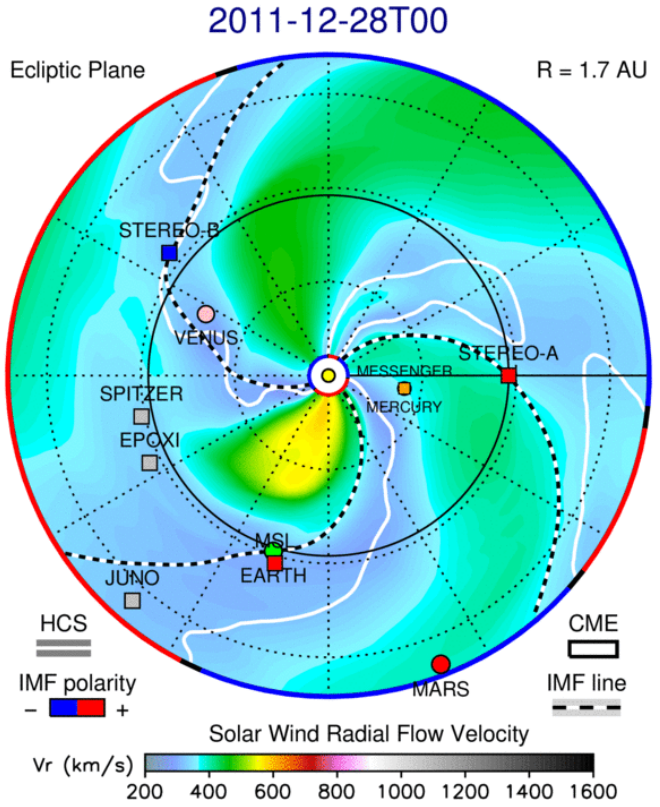


PSI: Janvier Wijaya, Jon Linker, Cooper Downs

CCMC: R. Mullinix, P. Macneice

Time Dependent WSA-ENLIL





- Until recently, models of the global corona and inner heliosphere have been driven by single static photospheric synoptic magnetograms.
- CCMC is redeveloping its Runs on Request and real-time systems to offer WSA-ENLIL simulations driven either by a sequence of time-interpolated magnetograms or ADAPT magnetograms.

C.N. Arge, D. Odstrcil, C.Henney)

Time-dependent ENLIL v2.8, v2.9 Status

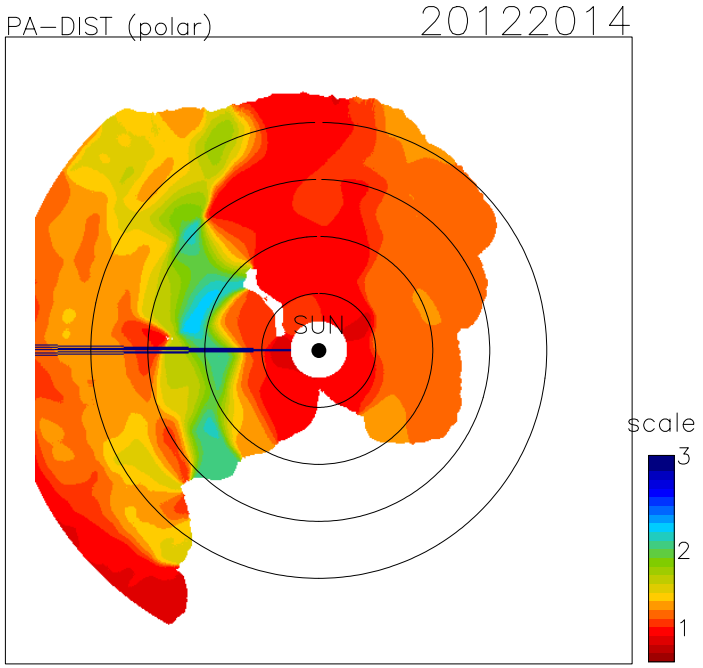
- **Full rotation ENLIL v2.8 simulations are available on Runs on Request.**
- The interface for **time-dependent** inner boundary simulations (without ADAPT) **is available for special requests now.** In the last year **290+ user special request simulations** have been executed.
- **Output page now provides** the new **ENLIL shock and fieldline output** to users.
- **ENLIL v2.9** (time-dependent) was delivered in February and will be made available to all users this year.

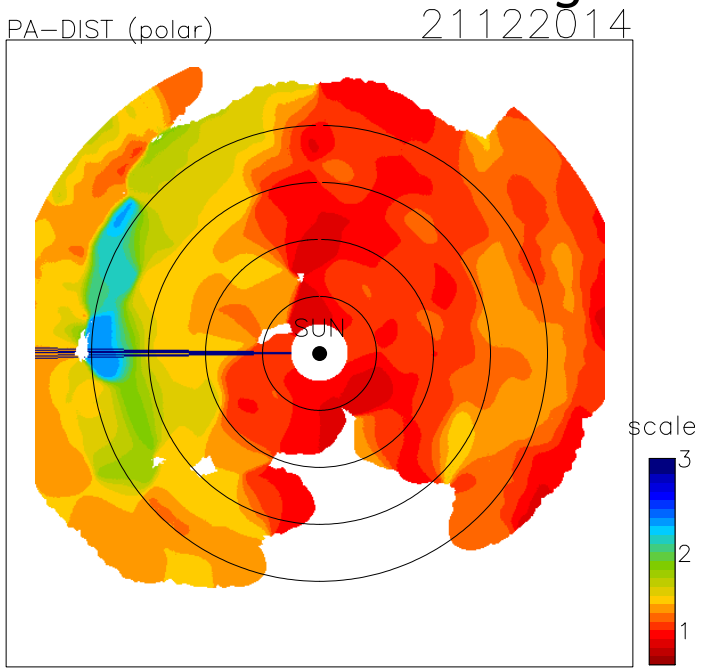
CCMC: Leila Mays, Peter Macneice

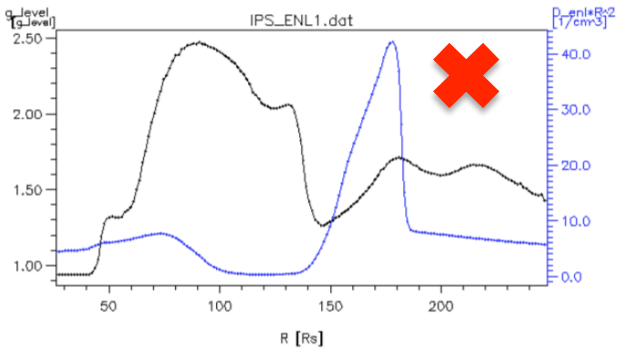
Developers: C.N. Arge, D. Odstrcil, C.Henney)

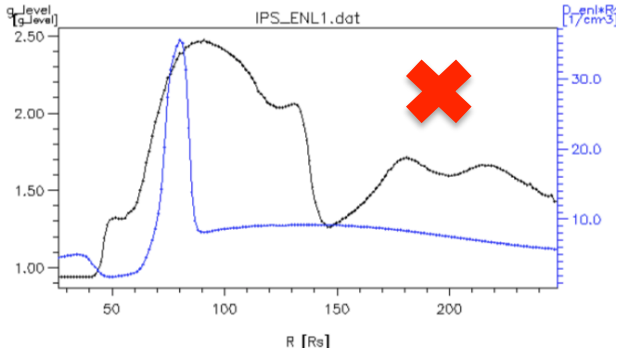
Using Interplanetary Scintillation Data to Improve Ensemble Modeling of CMEs

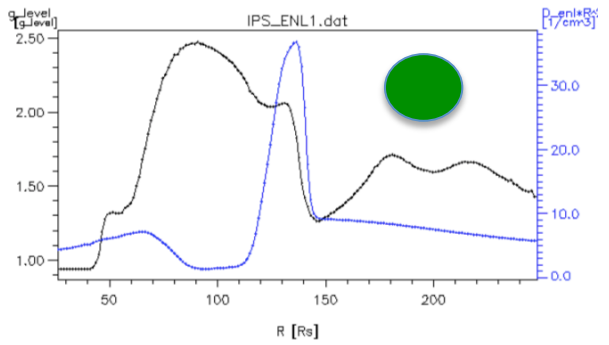
Can real time IPS observations improve ensemble modeling results?











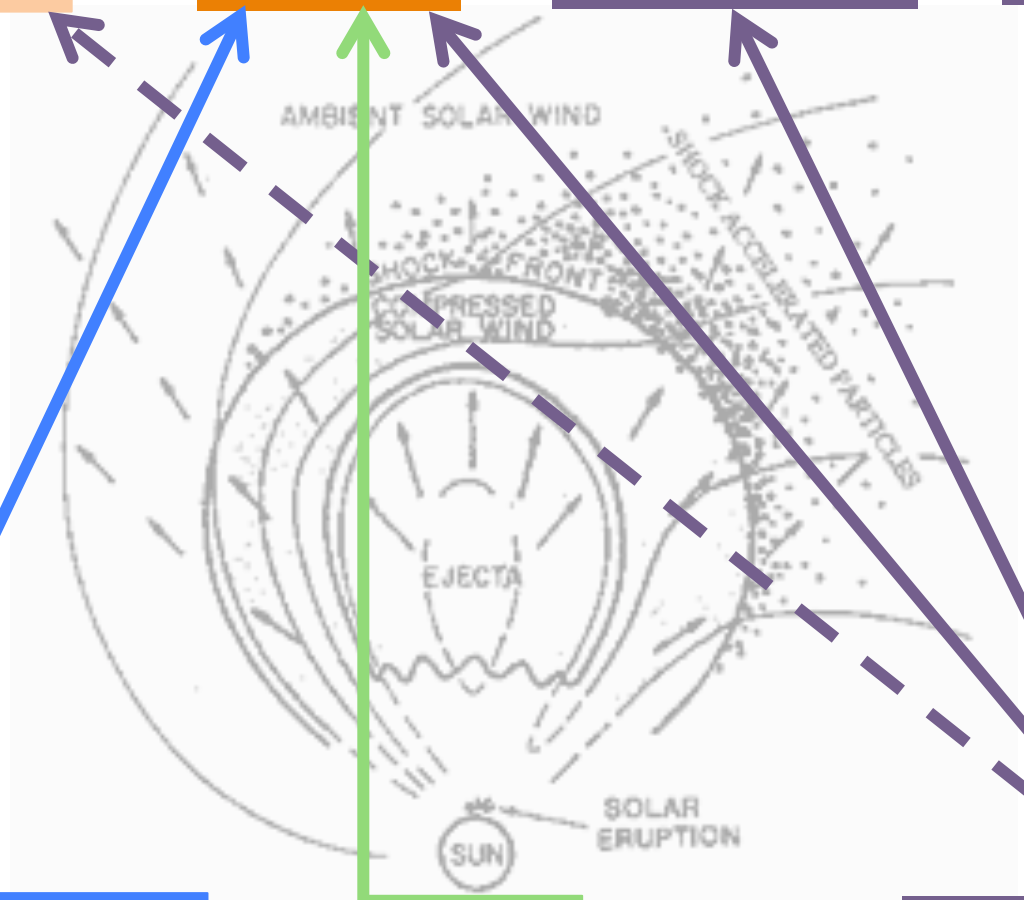
Taktakishvili et al., submitted to Space Weather

Towards coupled heliosphere and SEP models

CCMC is making steps towards offering a system to run SEP models driven by a variety of heliospheric models.

SEP MODELS

SEPMOD | EPREM | SWMF: FLAMPA | SWMF: Kota SEP



SOLAR-HELIOSPHERE MHD MODELS

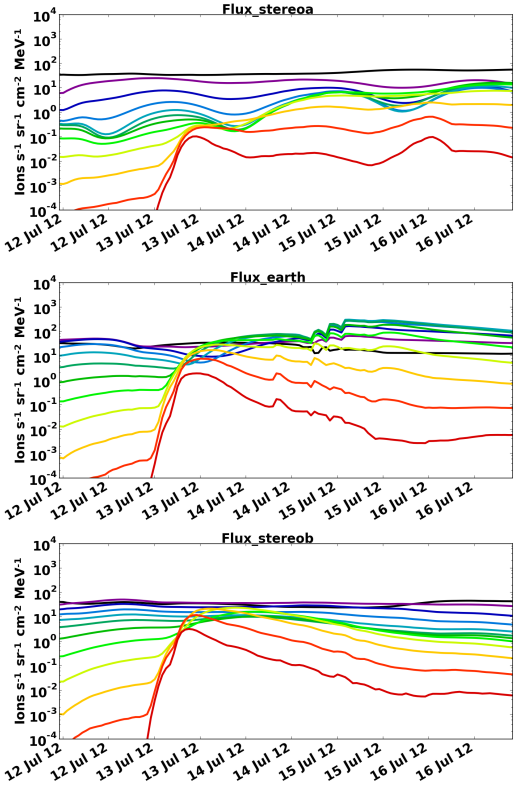
WSA-ENLIL+Cone | CORHEL | SWMF: AWSoM-R

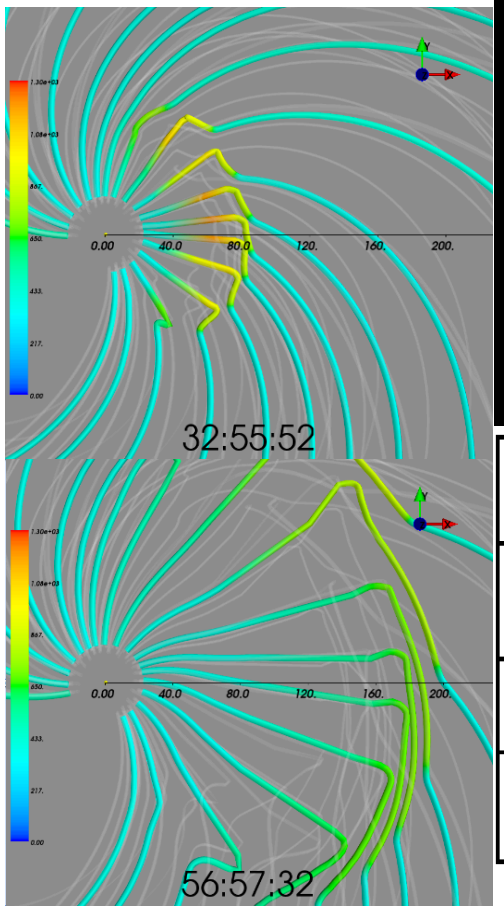
Hydrodynamic CME | *Flux Rope CME (Titov-Demoulin, Gibson-Low)*

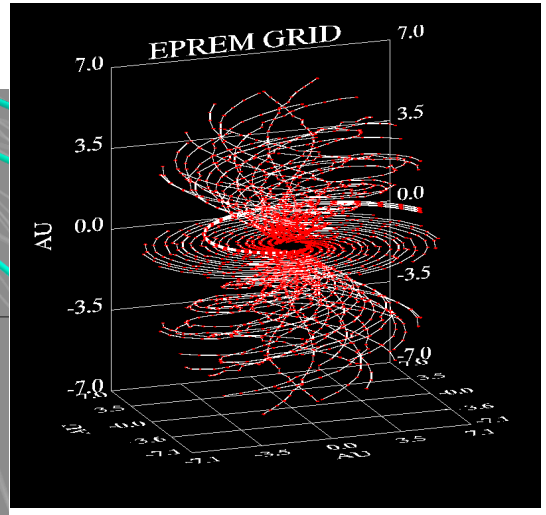
CCMC: Leila Mays

Modelers: N. Arge, D. Odstrcil, J. Luhmann, J. Linker, N.Schwadron, M. Gorby, I.Sokolov

CCMC Support of NASA/NSF Partnership Project:
Corona-Solar Wind Energetic Particle Acceleration (C-SWEPA) Modules







	Real-time - Available	Runs on Reqeust - Coming Soon	Runs on Request - Testing
PREDICCS	✓		
EPREM		✓	
EPREM+cone		✓	
Coupled WSA-ENLIL+EPREM			✓

CCMC: Leila Mays

- Weekly CCMC/C-SWEPA telecons collaborating on development and enhancement of model support.

New in magnetosphere modeling

- **VERB** (*Y. Shritz, A. Kellerman*) added to inner magnetosphere RoR:
  - Radiation belt model driven by GOES high-energy particle data and KP
  - Architecture based on Matlab and OpenMPI parallel models (L*, VERB)
- RAM-SCB (*V. Jordanova*, pending)
- IMPTAM (*N. Ganushkina*, pending)
- **CM5** added to Instant Run
  - Climatology of crustal, ionosphere and magnetosphere contributions to magnetic field in the ground
- **Space Weather Forecasting Toolkit SWFT** *(A. Mannucci, C. Wang)*

CCMC: Lutz Rastaetter, Y. Zheng

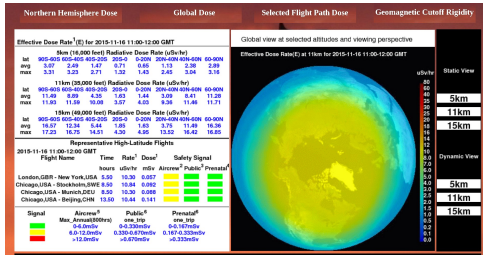
New/Updated IT Models Since Apr. 2016

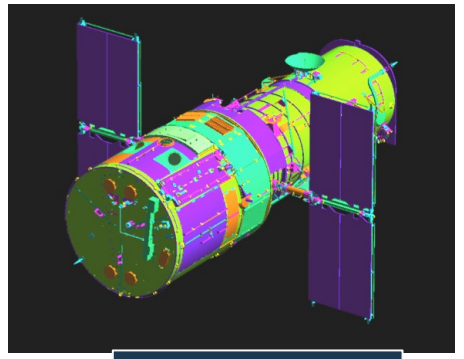
Domain	Model	Developers	Services
Thermosphere	**DTM 2013**	S. Bruinsma, CNES	RoR
Ionosphere	**TIE-GCM 2.0**	R. G. Roble et al., HAO, NCAR	
	GITM 2.5	A. J. Ridley et al., UM	
	USU-GAIM 3.1	R. W. Schunk et al., USU	RoR
High-latitude Electrodynamics	**HL-IDED-DA**	J. V. Eccles et al., CASS, USU	RoR, RT
Scintillation	**WBMOD**	J. Secan, NWRA	Ins. Run, RoR

CCMC: J-S. Shim

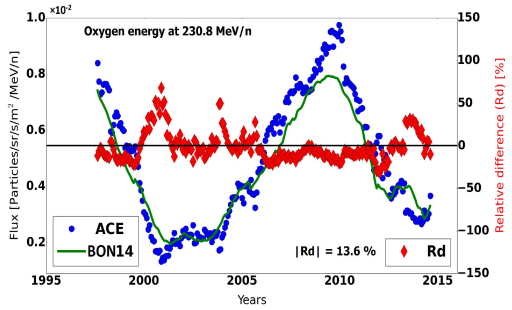
Radiation Effect Models

- **NAIRAS** (Nowcast of Atmospheric Ionizing Radiation System)
  - Assesses radiation exposure levels for aviation from GCRs and SEPs
  - Displays of realtime dose calculation available
  - NAIRAS 2.0 to be installed
- **PANDOCA** (Professional Aviation Dose Calculator)
  - Assesses radiation exposure levels for aviation from GCRs and SEPs
  - Displays of realtime dose calculation available
- **CARI-7 (pending)**
  - Calculates radiation dose from GCRs received by airline passengers/ crews
- **NOVICE (pending)**
  - Radiation effect code for spacecraft and/or component in complex geometries
  - Dose calculation completed for GOES location from 2010 - 2016
  - To be installed for realtime dose calculation
- **CREME96 (pending)**
  - Radiation effect code on hardware
  - Currently hosted at Vanderbilt U.
- **Badhwar-O'Neill (BON) 2014 GCR model**





HST from NOVICE



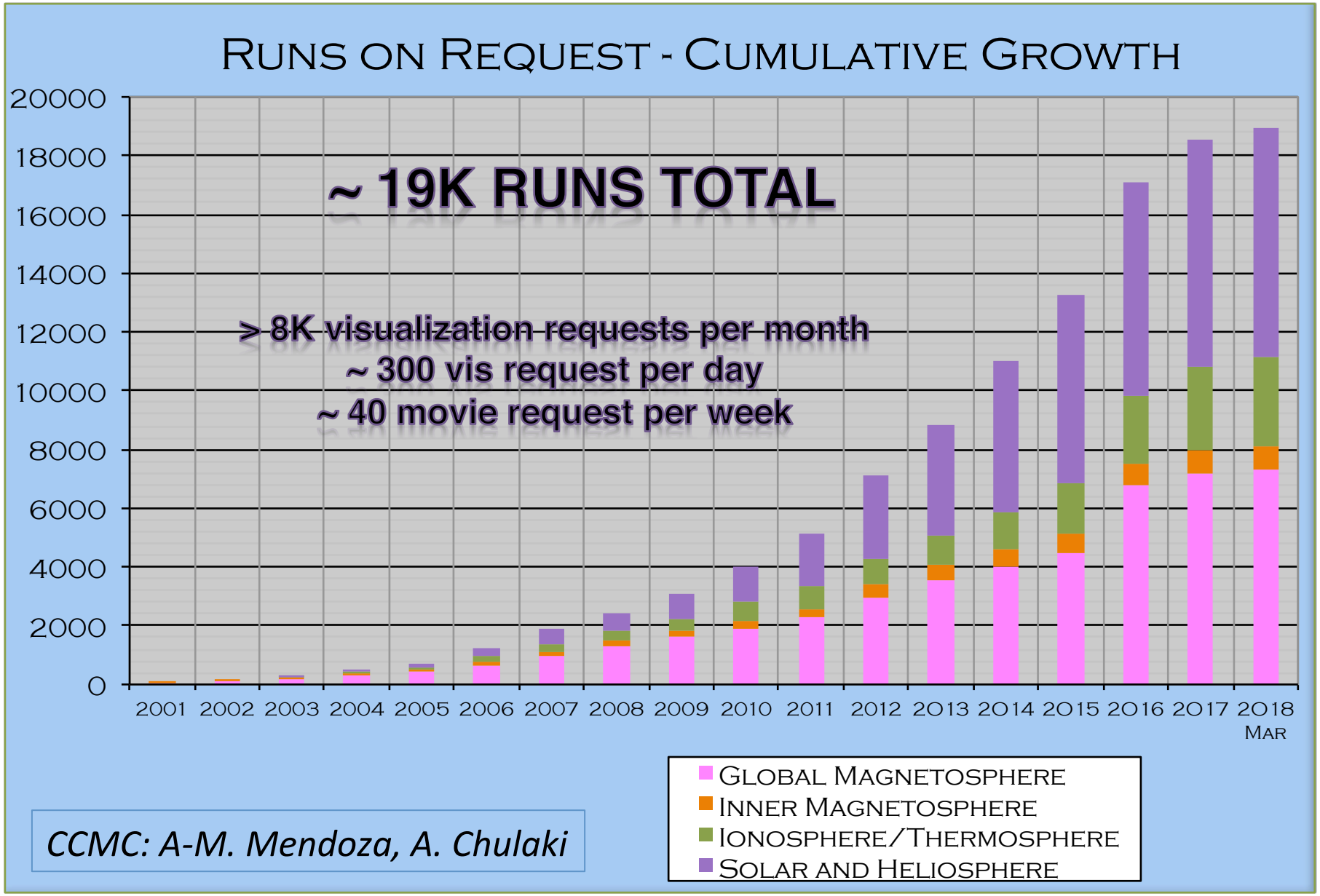
BON 2014

***Modelers**: C. Martens, M. Meier, K.Copeland, M. Xapsos, P.O'Neill, S. Golge*

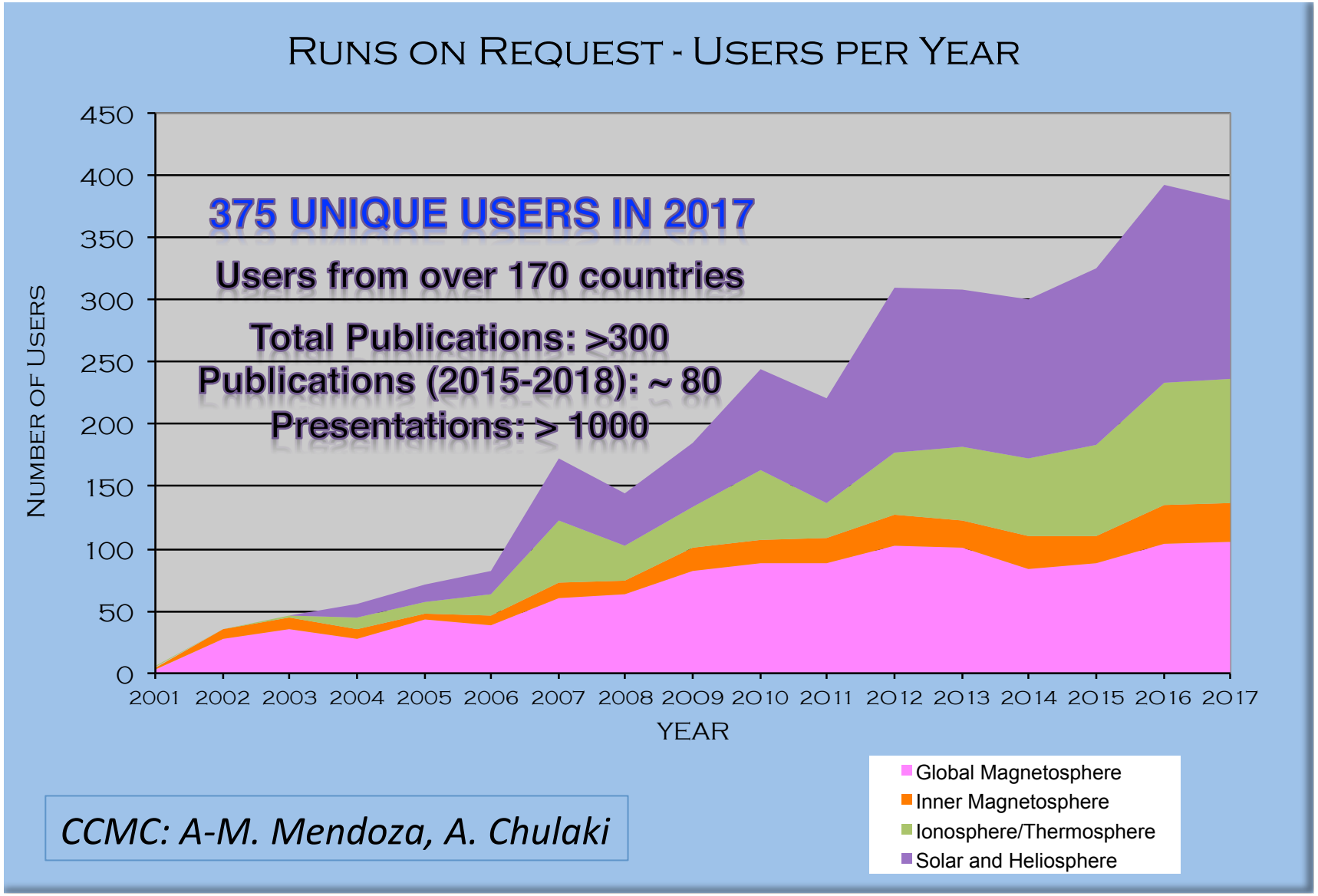
CCMC: Y. Zheng

Runs-on-Request

Usage Summary: RoR Growth

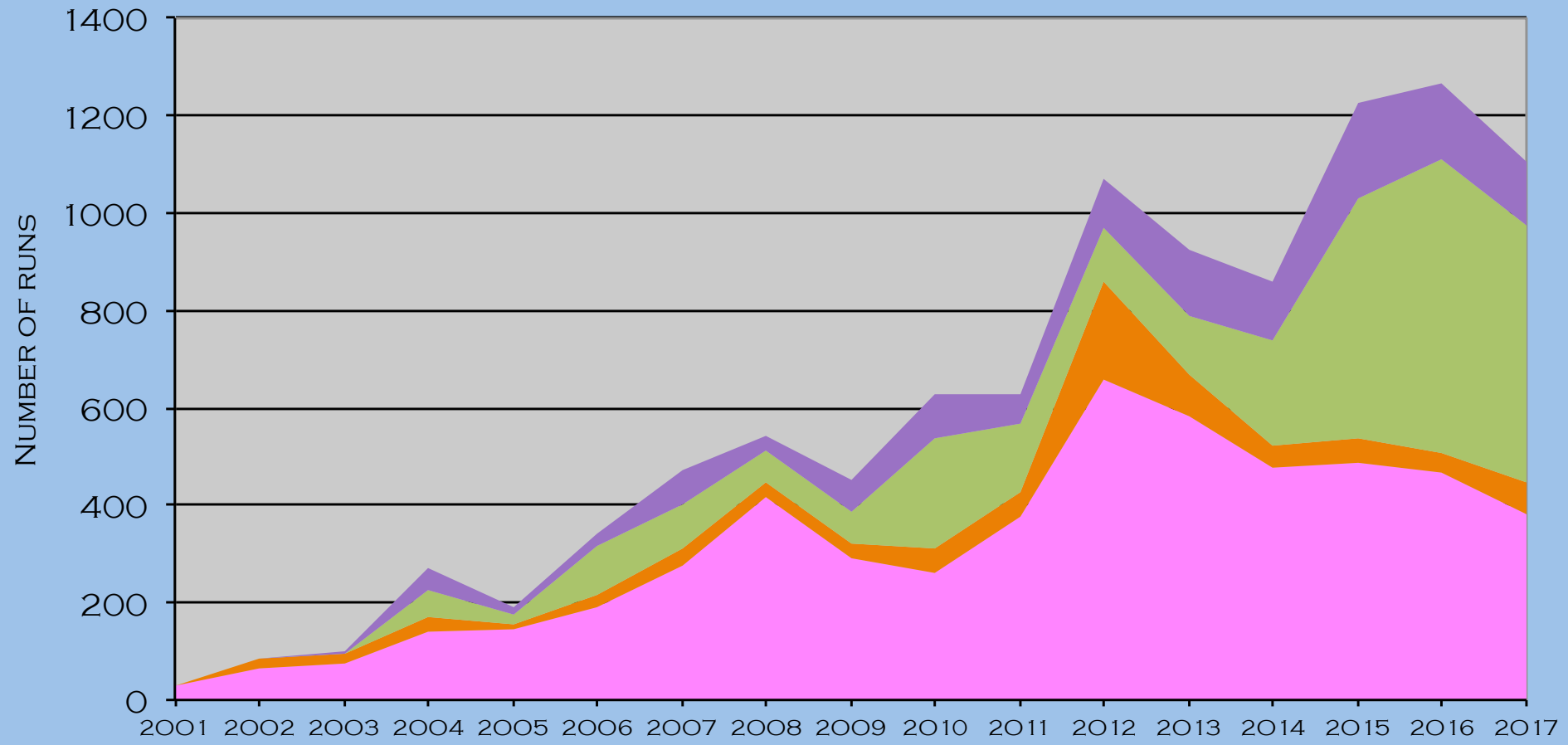


Runs-on-Request
Unique Users Growth



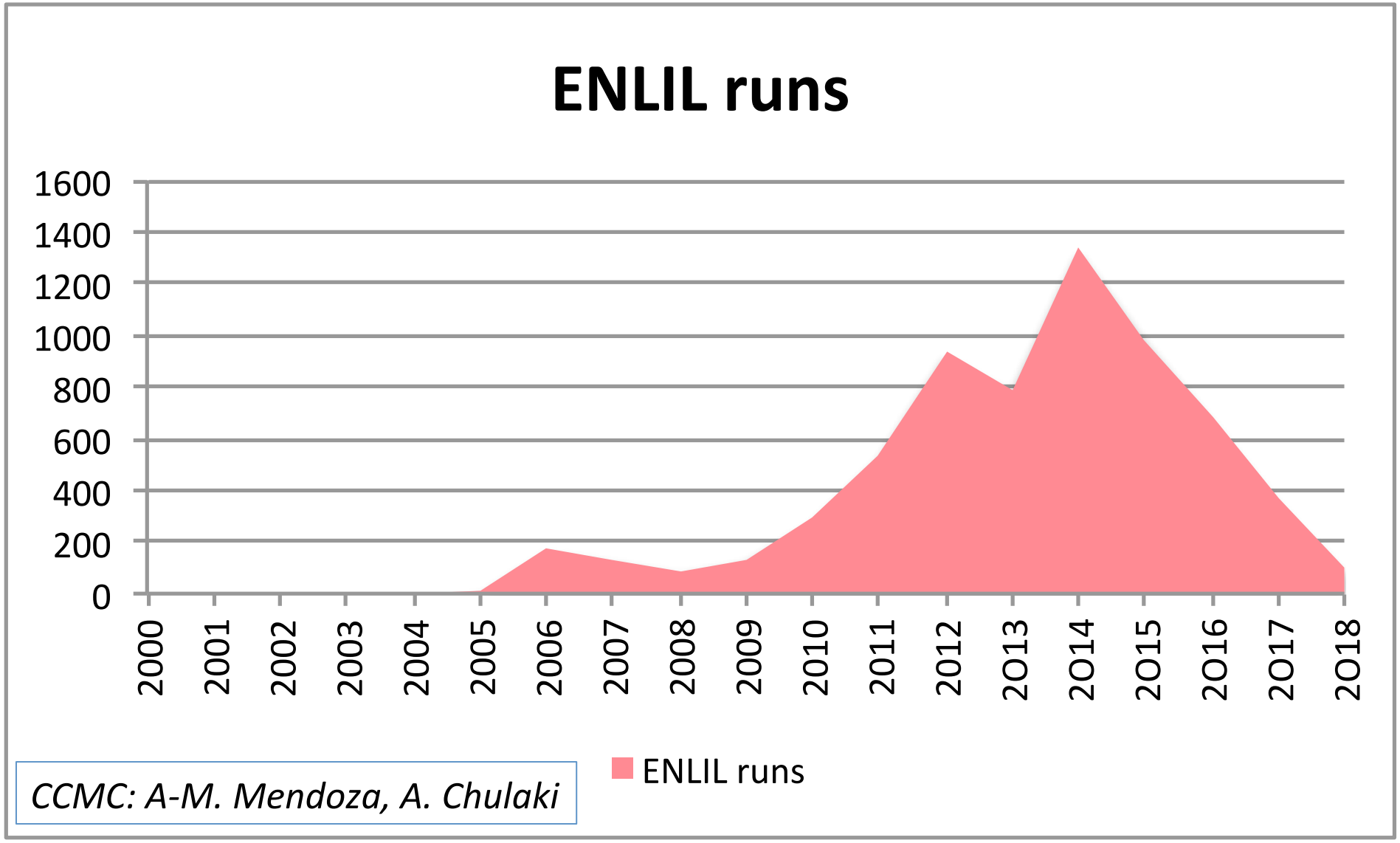
CCMC: A-M. Mendoza, A. Chulaki

Runs on Request - Executed per Year

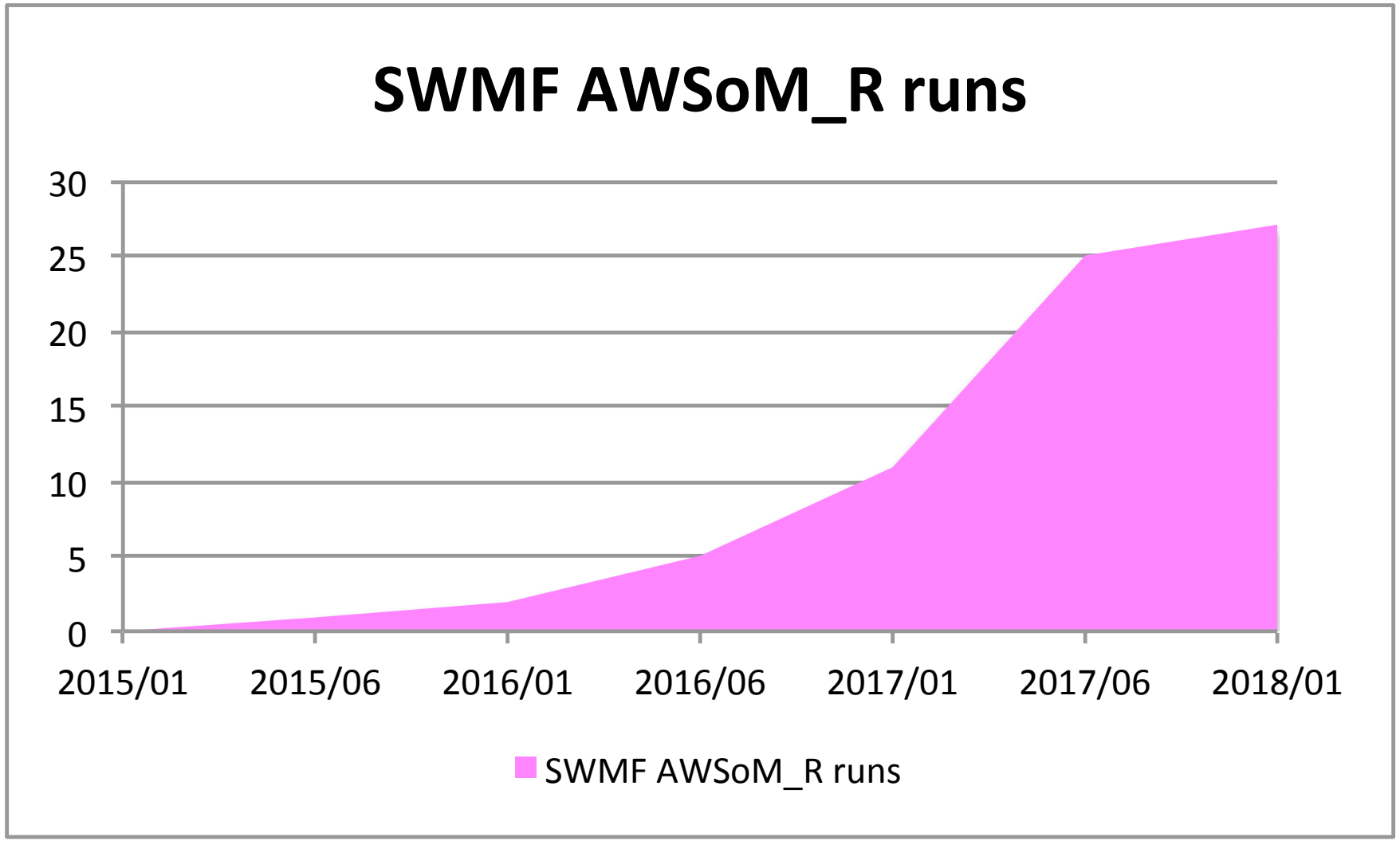


CCMC: A-M. Mendoza, A. Chulaki

Enthusiasm for Enlil peaked in 2014



Number of runs for computationally intensive models is limited by the CCMC computational resources



CCMC: A-M. Mendoza, A. Chulaki

Testing & Validation

Event-based M&V
to trace model improvement, sensitivity to external drivers and internal assumptions

A list of **events**.
High quality **data**.
A library of **metrics** relevant to specific space weather applications.

Simulate the same set of events over and over…

Real-Time Prototyping
Evaluation of operation readiness

Testing predictive capability
before the event onset

CME Scoreboard

Flare Scoreboard

SEP Scoreboard

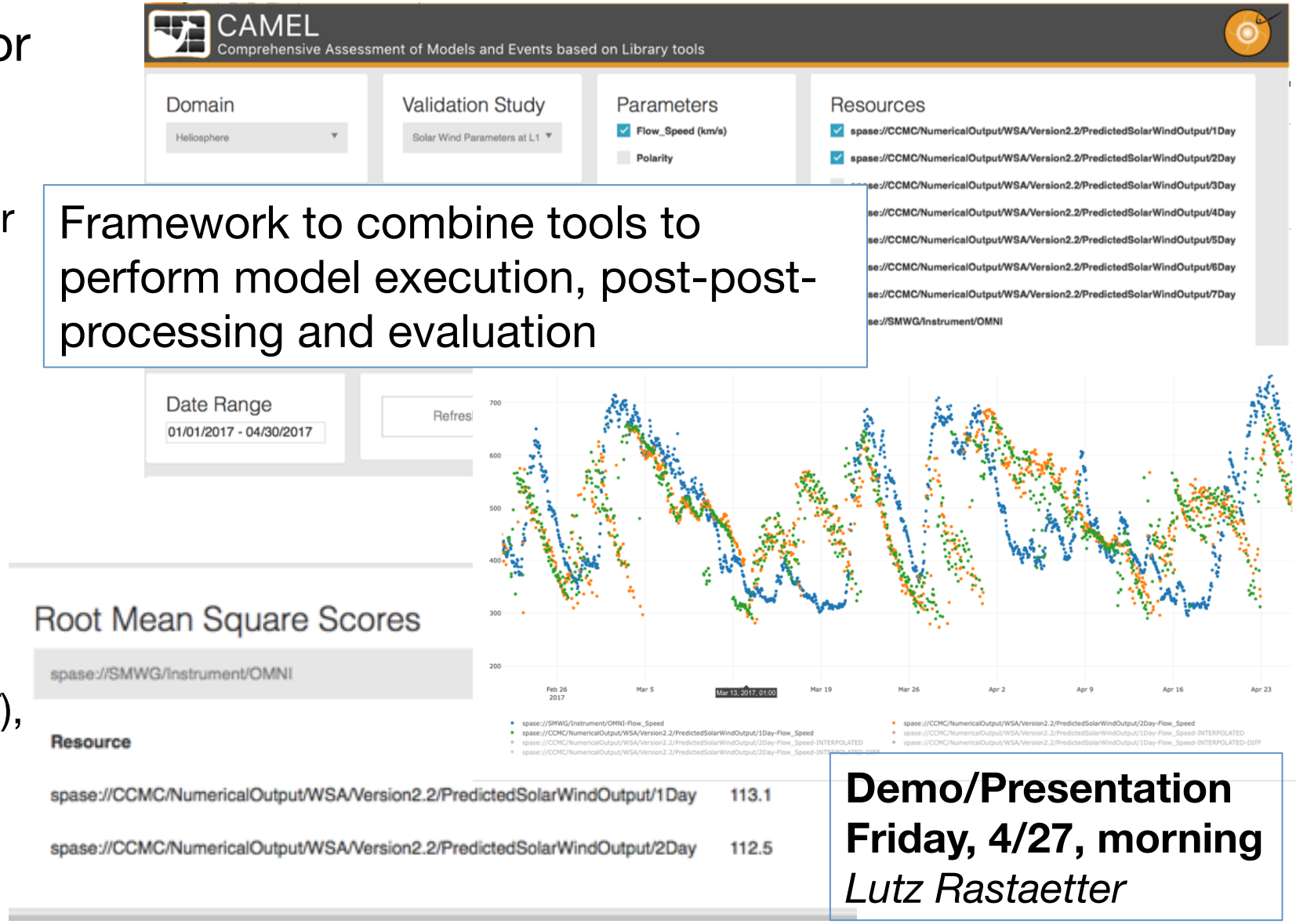
NASA CCMC – NOAA SWPC Working Together

- Collaborative effort to assess improvements in space weather forecasts at Earth by moving from driving the ambient inputs for the WSA-Enlil model from a single daily-updated magnetogram
  - to a sequence of time-dependent magnetograms
  - the newly developed ADAPT.

- **NOAA SWPC / NASA CCMC Space Weather Modeling Assessment Project: Toward the Validation of Advancements in Heliospheric Space Weather Prediction Within WSA-Enlil**
  Eric Adamson, Vic Pizzo, Doug Biesecker (NOAA),
  M. Leila Mays, Peter Macneice, Aleksandre Taktakishvili (CCMC)
  - AGU presentation (Dec 2017)
  - Paper to be submitted to SWJ Special Issue on Space Weather Capabilities Assessment (May 2018).

Comprehensive Assessment of Models and Events based on Library tools (CAMEL)

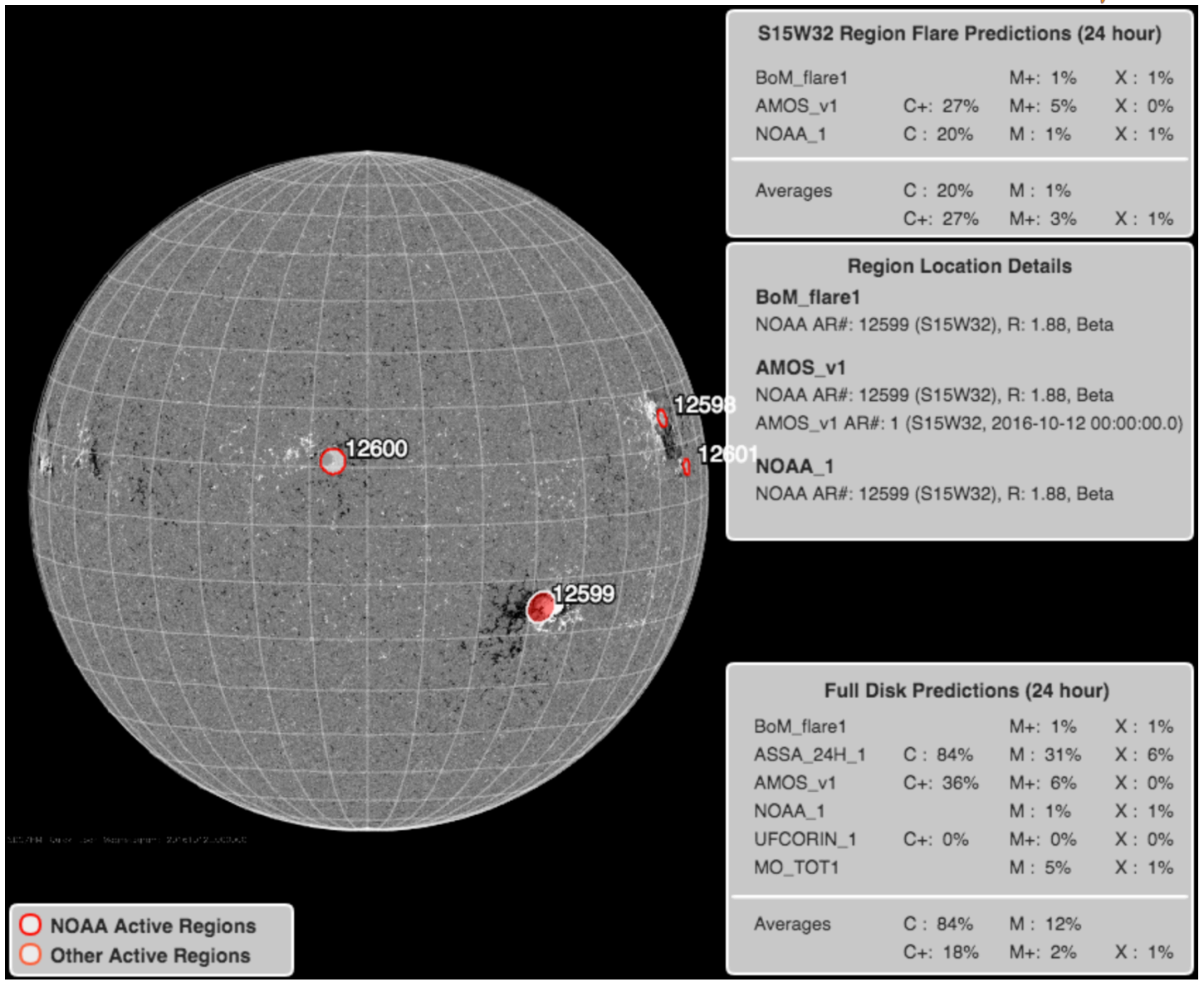
- Upcoming validation tool for historic time intervals
  - Stored model outputs and observation data timelines for all validation studies
  - Plot model and observation data together
  - Use library of comparison metrics (run_metric.vis.cgi):
  - RMS error, Prediction Efficiency, Event-Based
  - Partnership with NCAR Model Evaluation Tools (MET), *Tara Jensen, NCAR*



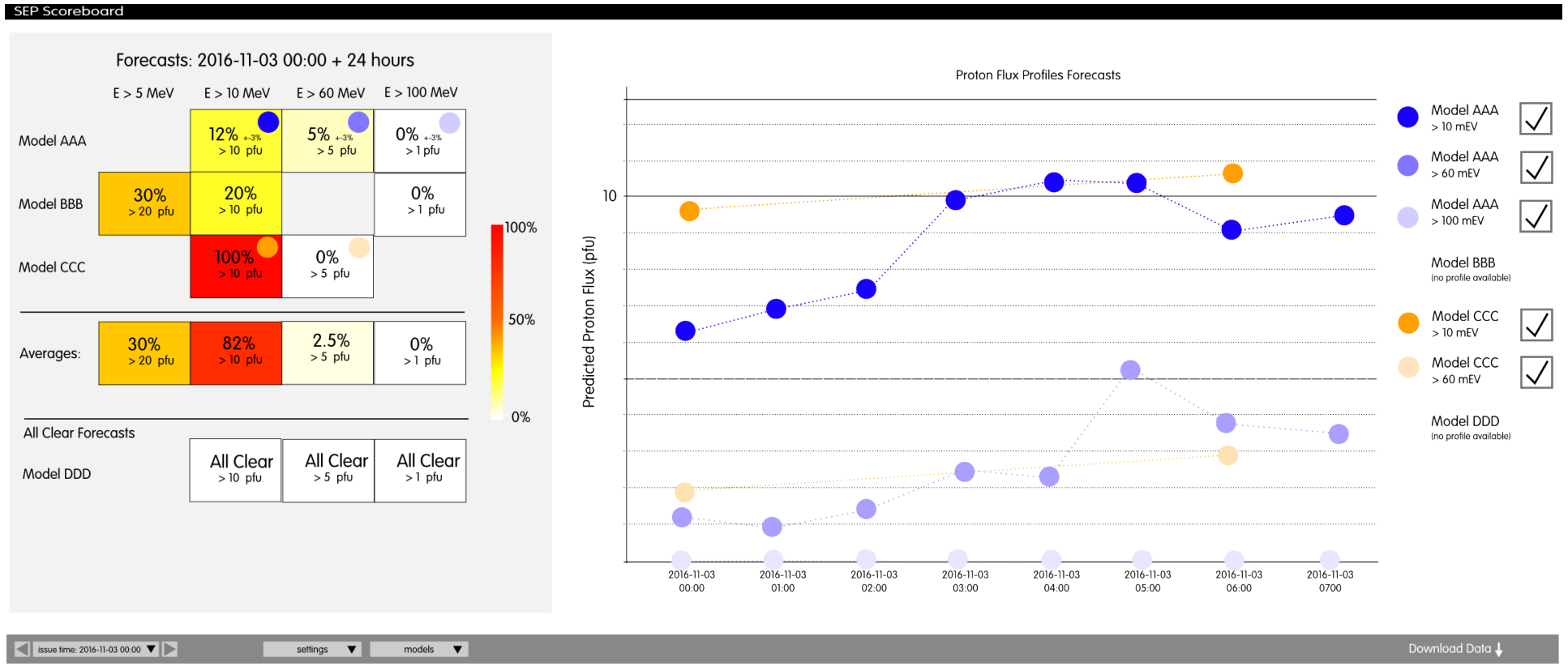
Flare Scoreboard

https://ccmc.gsfc.nasa.gov/challenges/flare.php

- Allows a consistent real-time comparison of various operational and research flare forecasts.
- Automated system; model developers can routinely upload their predictions to an anonymous ftp
- Forecast data is parsed and stored in a database which accessible to anyone via an API
- Planning group includes expert scientists as well as operational space weather prediction centers.



SEP Scoreboard Planning
Display ideas



Probability heat map at a single time

Predicted proton flux time-series

https://ccmc.gsfc.nasa.gov/challenges/sep.php

International CCMC – LWS Workshop, April 3-7, 2017

Assessing of Space Weather Understanding & Applications

Jump-start activities of the ***International Forum for Space Weather Capabilities Assessment***

~ 120 participants, ~ 20 working teams

Hands-on working sessions. Discussions. Deliverables.

Schedules & assignments for completion during the next year.

Continue interaction through regular telecons and in-person mini meetings (at workshops/conferences through the year)

Goals:

- **Define metrics for essential space weather quantities**
- **benchmark the current state**
- **trace progress overtime.**

SUPERTOPIC: QUANTIFYING SCIENTIFIC PROGRESS

CCMC facilitator: Barbara Thompson

19 focused evaluation topics grouped by 6 sub-domains, + 2 super-topics

- Assessment of Understanding and Quantifying Progress Toward Science Understanding and Operational Readiness
  (Leads: A. Halford, Steven Morley, Adam Kellerman, B. Thompson)

Can be sorted by LWS SSAs

SOLAR DOMAIN AGENDA

CCMC facilitator(s): P. Macneice

- Solar Flare Prediction (Leads: S. Murray, M. Georgoulis, S. Bloomfield, K.D. Leka
  Scoreboard Leads: S. Murray, M.L Mays) SSA-0,SSA-6 TEAM AGENDA
- Coronal & Solar Wind Structure
  Coronal & SW Structure; Ambient SW; Coronal Hole Boundaries
  (Leads: P. Macneice, L. Jian) SSA-? TEAM AGENDA
- 3D CME kinematics and topology (Leads: B.Thompson, C.Moestl, D.Barnes) TEAM AGENDA
- Solar Indices and Irradiance (Leads: J. Klenzing, C. Henney, K. Muglach) SSA-0 TEAM AGENDA

GEOSPACE: Geomagnetic Environment DOMAIN AGENDA

CCMC facilitator(s): L.Rastaetter

- Ground Magnetic Perturbations: dBdt, delta-B, GICs, FACs
  (Leads: D. Welling, H. Opgenoorth, C. Ngwira) SSA-1 TEAM AGENDA
- Geomagnetic Indices (Leads: M. Liemohn) SSA-1 TEAM AGENDA
- Magnetopause location and geosync. orbit crossing
  (Leads: Y. Collado-Vega, S. Merkin) SSA-1 TEAM AGENDA

HELIOSPHERE DOMAIN AGENDA

CCMC facilitator(s): M.L. Mays, A. Taktakishvili, P. Macneice

- CME Arrival Time (Leads: C. Verbeke, M.L. Mays, A. Taktakishvili) SSA-1 TEAM AGENDA
- IMF Bz at L1 (Leads: N. Savani, P. Riley) SSA-1 TEAM AGENDA
- SEPs (Leads: I.G. Richardson. P. Quinn, M. Marsh, M.L. Mays
  Scoreboard Leads: M. Dierckxsens, M. Marsh) SSA-3,SSA-6 TEAM AGENDA

GEOSPACE: Auroral Region DOMAIN AGENDA

CCMC facilitator(s): M.Kuznetsova

- Auroral precipitation and high latitude ionosphere electrodynamics
  (Leads: R. Robinson, Y. Zhang, B. Kosar) TEAM AGENDA

RADIATION and PLASMA EFFECTS DOMAIN AGENDA

CCMC facilitator(s): Y. Zheng, M. Kuznetsova

- Surface Charging *few eV - keV electrons, plasma density*
  (Leads: J. Minow, D. Pitchford, N. Ganushkina) SSA-6 TEAM AGENDA
- Internal Charging *keV–MeV electrons*
  (Leads: P. O'Brien, Y. Shprits) SSA-6 TEAM AGENDA
- Single Event Effects *MeV–GeV-TeV protons, ions*
  (Leads: M. Xapsos, J. Mazur, P. Jiggens) SSA-3,SSA-6 TEAM AGENDA
- Total Ionizing Dose *keV–MeV electrons, keV–GeV protons,ions*
  (Leads: I. Jun, T. Guild, M. Xapsos) SSA-6 TEAM AGENDA
- Radiation effects for aviation (Leads: K. Tobiska, M. Meier) SSA-6 TEAM AGENDA

IONOSPHERE DOMAIN AGENDA

CCMC facilitator(s): J. Shim, M. Kuznetsova

- Neutral Density and Orbit Determination at LEO
  (Leads: S. Solomon, T. Fuller-Rowell, S. Bruinsma, E. Sutton) SSA-2 TEAM AGENDA
- Global & Regional TEC (Leads: L. Scherliess, R. Calfas) SSA-4 TEAM AGENDA
- Ionosphere Plasma Density: NmF2/foF2, hmF2, TEC
  (Leads: I. Tsagouri, M. Angling, J. Shim) SSA-5 TEAM AGENDA
- Ionosphere Scintillation (Leads: E. Yizengaw) SSA-5 TEAM AGENDA

INFORMATION ARCHITECTURE

CCMC facilitator: Chiu Wiegand

SPASE metadata implementation

Cross-team interactions

- Information Architecture for Interactive Archives (IAIA) (Leads: C. Wiegand, D. Heynderickx, D. De Zeeuw, T. King)

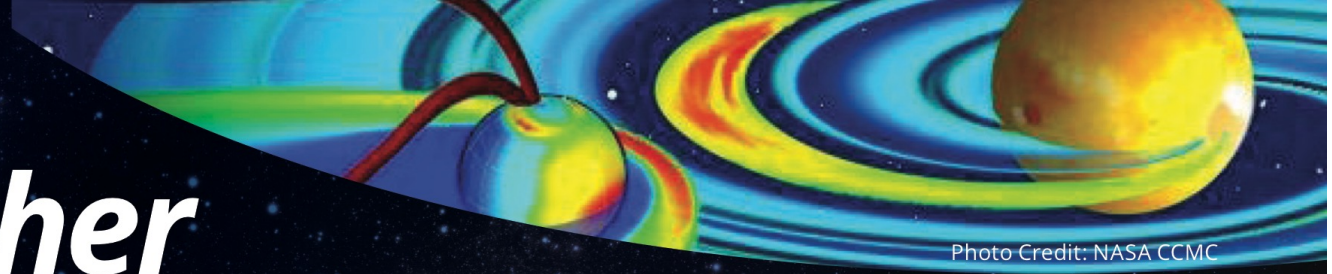


Photo Credit: NASA CCMC

Space Weather

Call For Papers:
Space Weather Capabilities Assessment

Space Weather is seeking manuscripts for a special collection highlighting the progress of working teams of the International Forum on Space Weather Capabilities Assessment.

Topics include:

- Defining metrics for essential space weather quantities
- Benchmarking the current state of space environment models, applications and forecasting techniques
- Addressing challenges in data-model comparisons
- Tracking progress in incorporation of scientific ideas into space weather applications

While the focus of this special collection is contributions from the Forum working teams, related manuscripts from the community are also invited.

Learn more at **spaceweather.agu.org**

AGU100 ADVANCING EARTH AND SPACE SCIENCE

Expecting about 20 submissions from Forum teams

WILEY

18 - 360803

Prototyping of forecasting techniques

GSFC

BzTool

INPUT: Cone or GCS model

Solar Storm Origin	Lat:	-15.0
	Lon:	14.0
Axis Tilt angle		30.0
Half Angular Width		58.0

INPUT: Solar Surface

Leading polarity of Source Region: [+] Positive

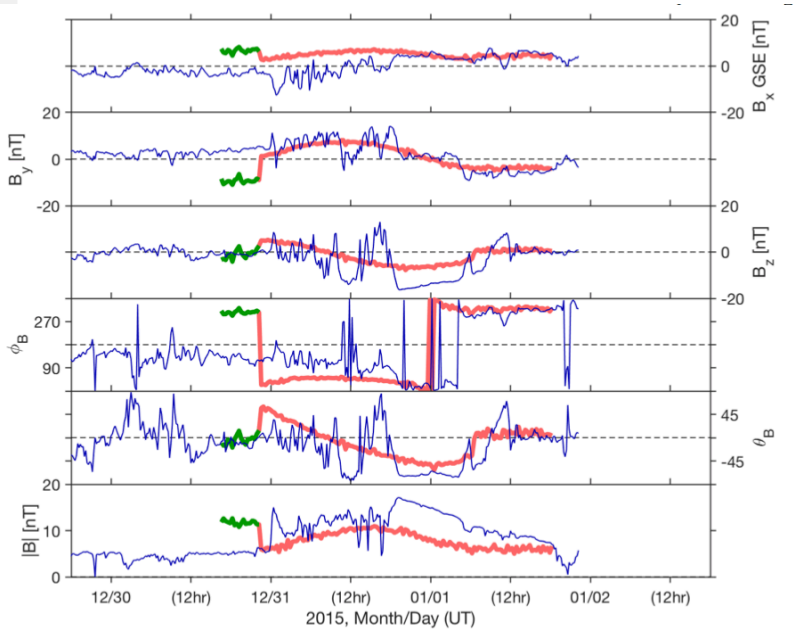
INPUT: SWRC Enlil Forecast Values

Leading Edge Arrival Time	2015,12,30,22,30,00
|B| max prediction at L1 [nT]	13.0
|V| max prediction at L1 [km/s]	645

Bz Prediction

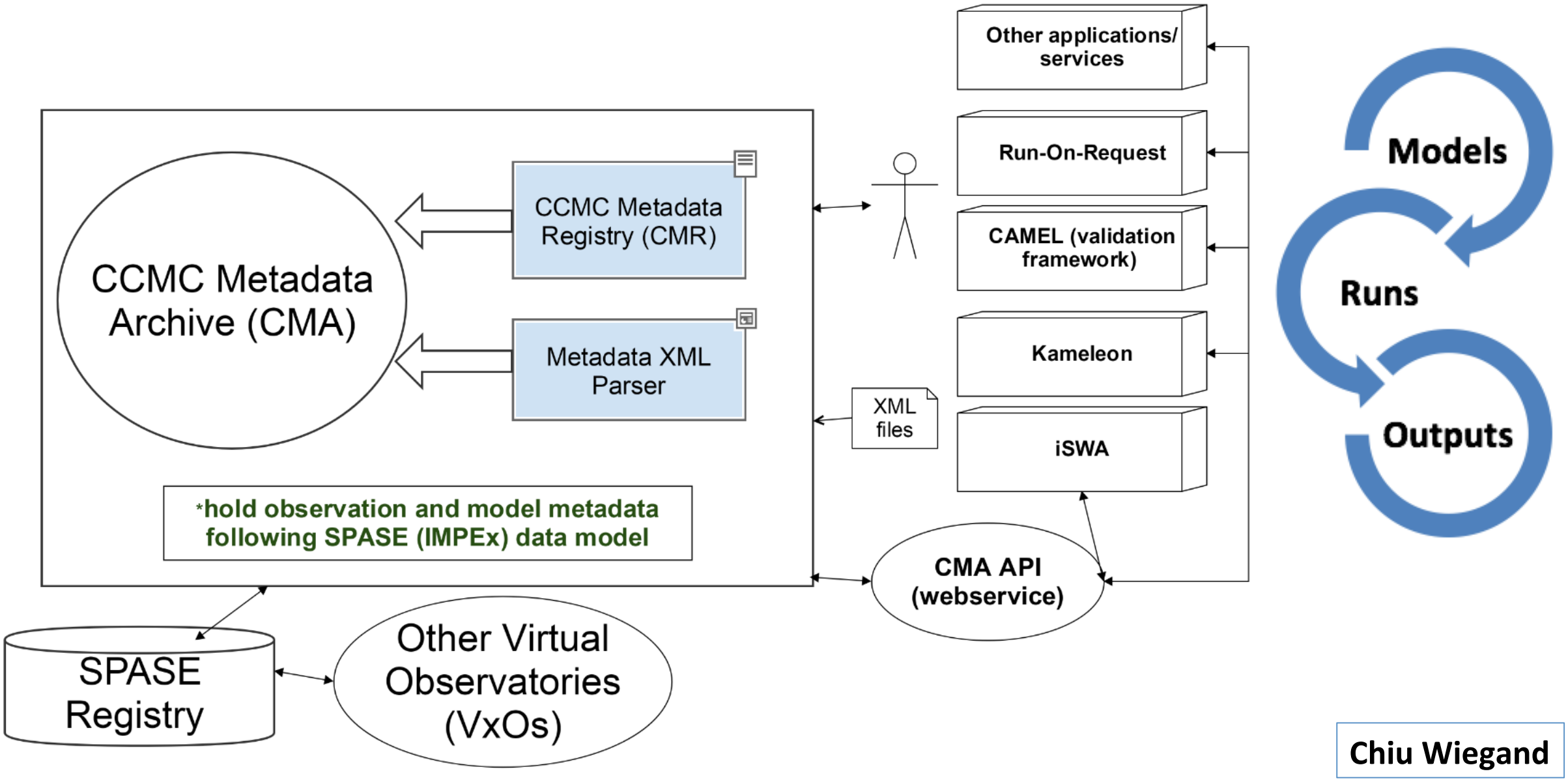
version: 8.4

Bz4Cast model (N. Savani)



Space weather forecasting & prototyping team lead: *Yari Collado-Vega*

Metadata for CCMC Interactive Archives



Chiu Wiegand

Dedicated Computational Infrastructure

4045 CPUs

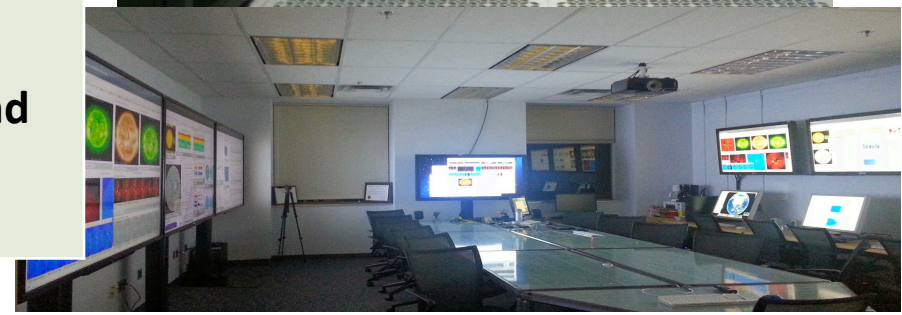
5 Clusters
with total of 156 nodes
(1860 CPUs)

2 petabytes of storage
(6 storage raid w/
controllers)

53 Servers
for various purpose

10 GB dedicated
GSFC SEN

27+ Licenses
(Intel, PGI, MatLab and
IDL)



Tina Tsui (lead), Sarabjit Bakshi, Kiran Patel

RoR visualization

- Oblique cut slices:
  - LT=constant or MLT=constant
  - arbitrary plane normal
  - different target coordinate system (SM,GSM,GSE)

RoR input generation

- DSCOVR real time added
- optional filter to eliminate spikes in plasma data
- DSCOVR L2 coming soon

CCMC: Lutz Rastaetter

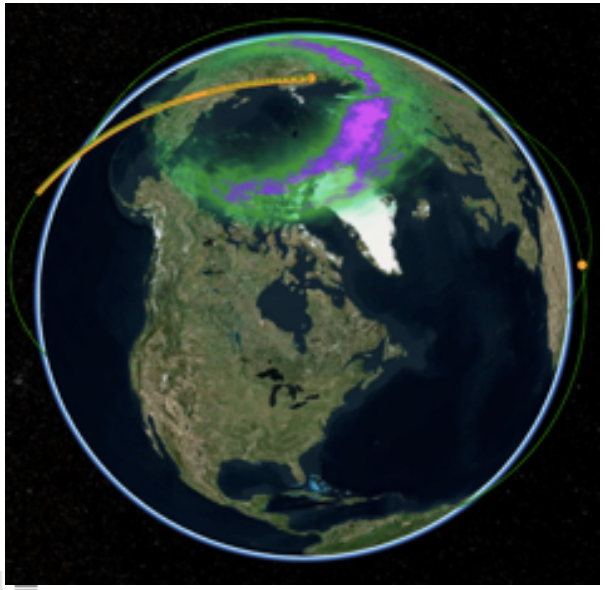
RoR postprocessing

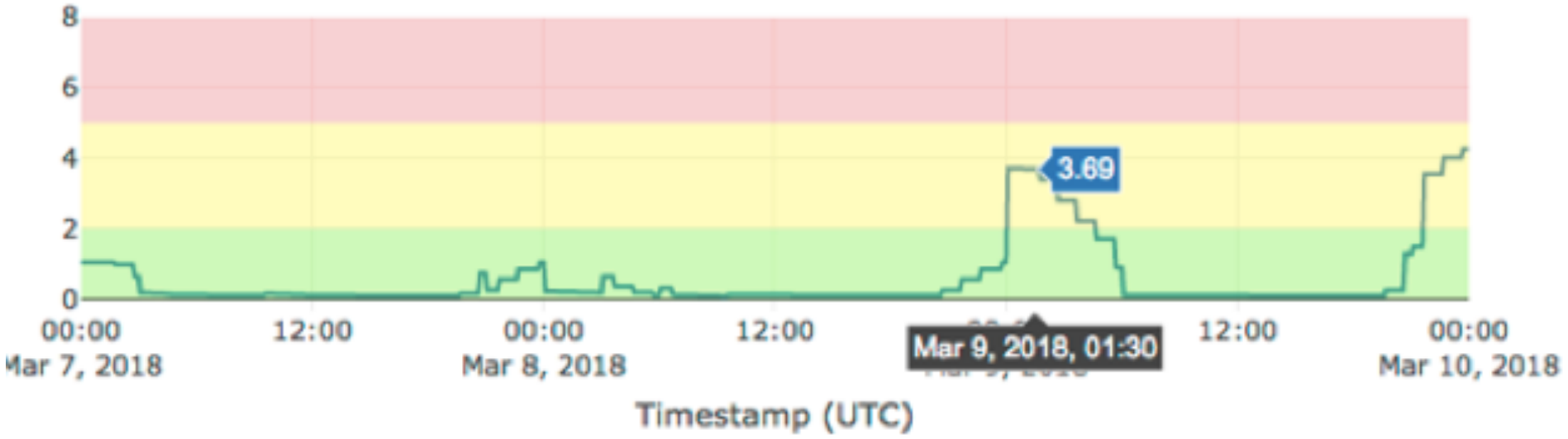
- **ReconX** (*A Glocer, C. Komar*):
  - Derive high-resolution magnetic topology boundaries in dayside magnetosphere
    - implemented as PostProcessing (PP) request run
- **AMPS** (*V. Troshichev*):
  - Particle tracing using existing magnetosphere model runs
    - Selection of multiple ion species
    - time-dependent magnetosphere solution
  - Interactive visualization using Plotly

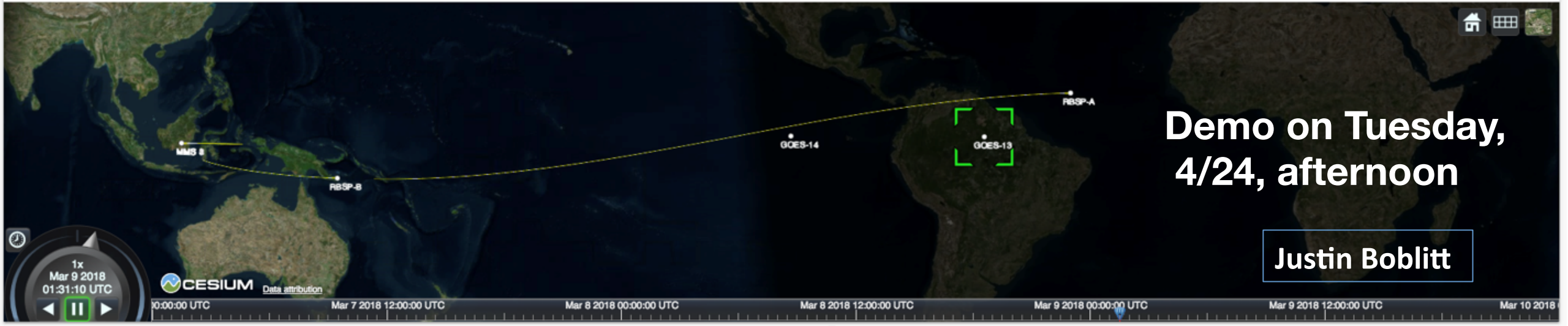
CCMC: Lutz Rastaetter

GSFC

Space Environment Automated Alerts and Anomaly Analysis Assistant, SEA5 (on-going development)

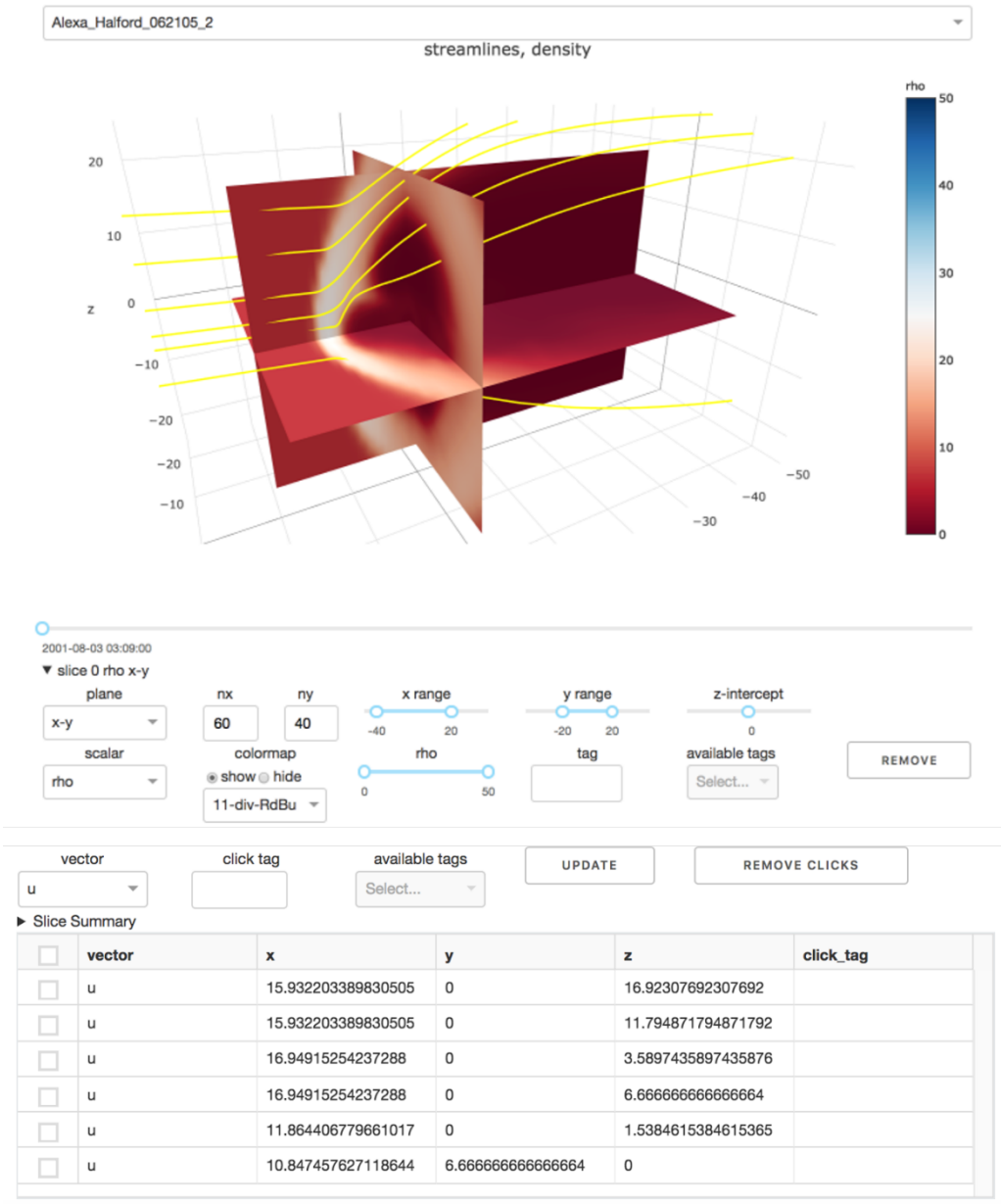






Kameleon Web Visualizer (on-going development)

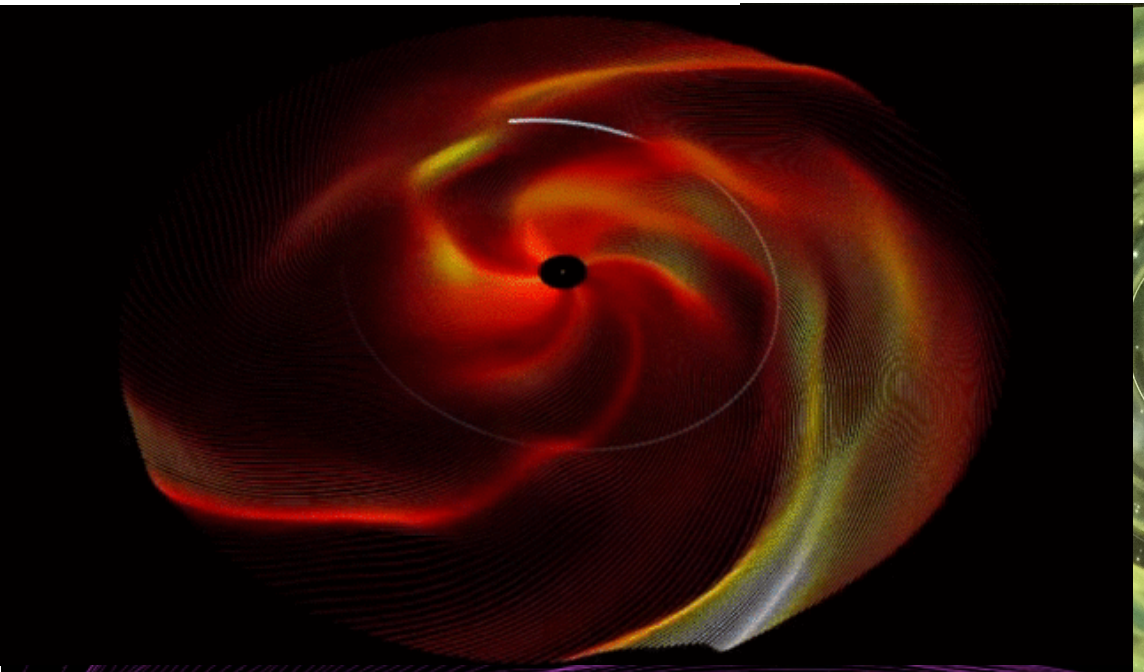
- **Kameleon Web Visualizer**: An Interactive 3D Web Analysis Tool
  - Integrated with RoR database
  - Cut-Plane Selection
  - Seed Point Picker
  - Region-of-interest Tags
- **Demo on Tuesday, 4/24, afternoon**

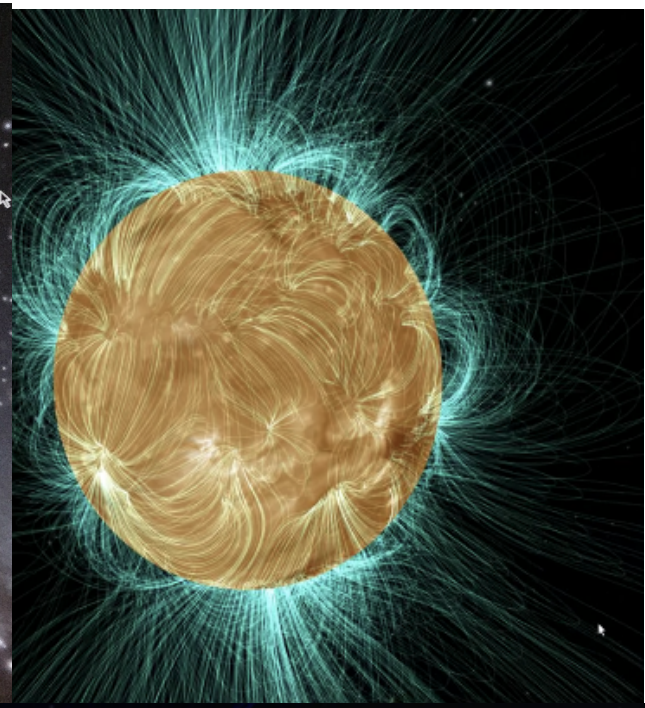


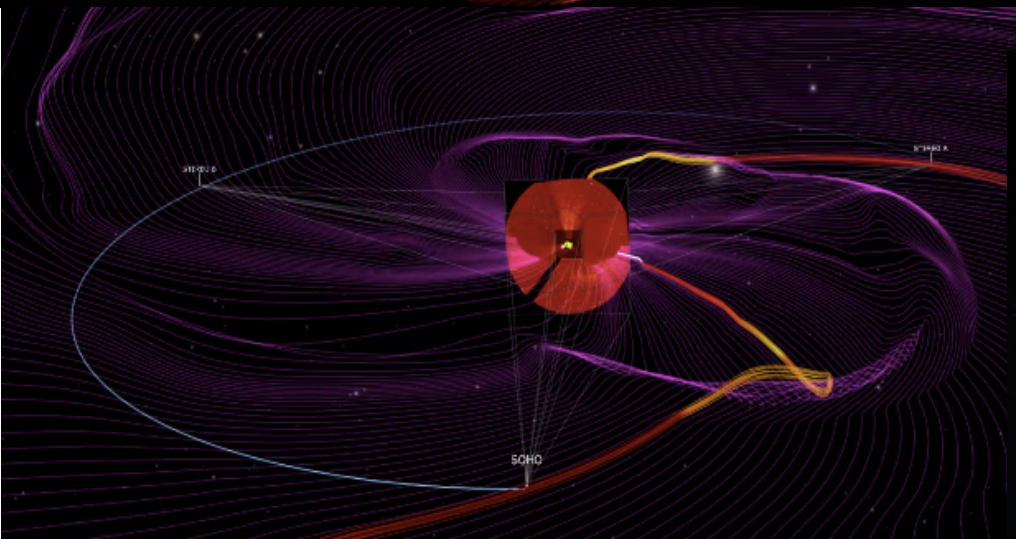
Asher Pembroke

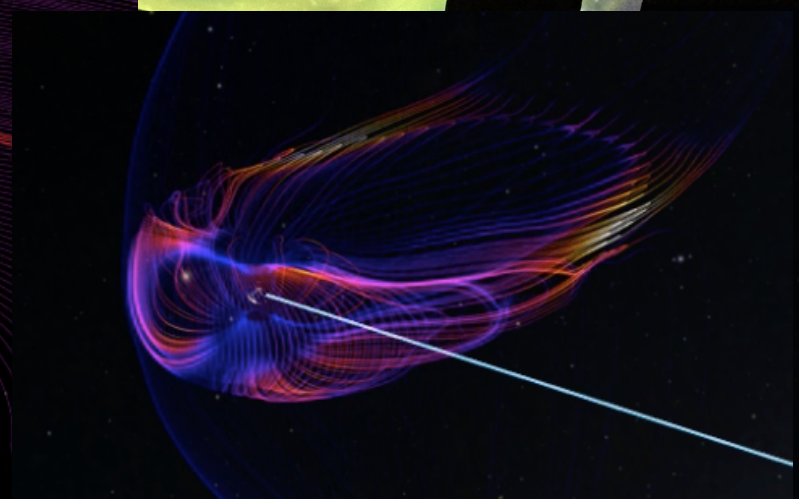
OpenSpace (CCMC-AMNH-LiU Partnership):

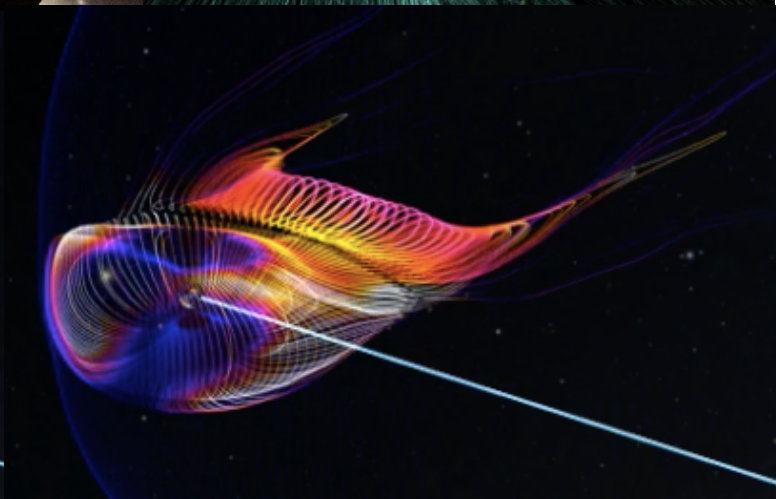
Advanced visualization for public outreach and research











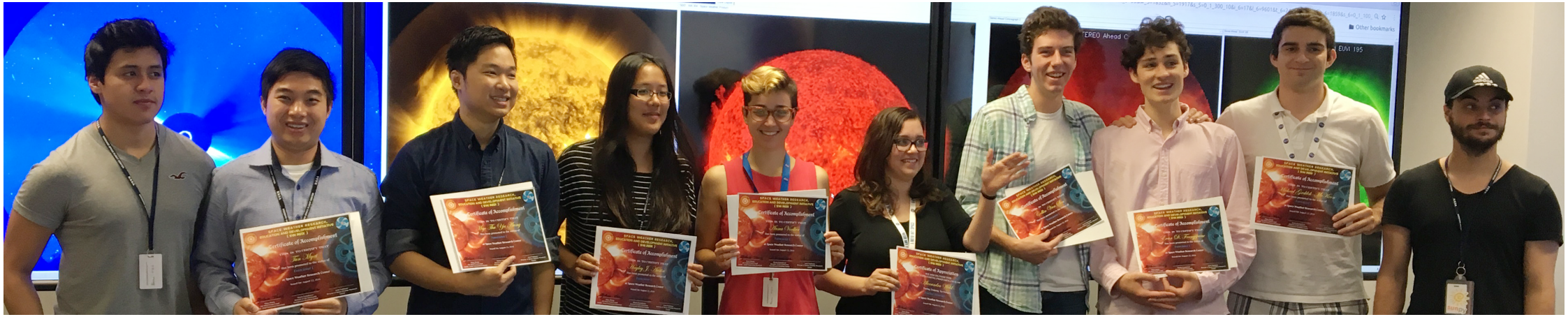
Space weather education and training

Annual week-long space weather REDI Bootcamp

- Held for the last 7 years
- Yearly attendees: about 60
- Participant composition: growing % of underrepresented students

Summer and year around internship

- Held for the last 7 years
- Almost 90 student interns in the last 7 years:
  - Space weather forecasting
  - Space weather research
  - Software development



Presentation on Wednesday, 4/25, afternoon

Education lead: *Anna Chulaki*

CCMC Staff

T. Tsui
(Hardware lead)

S. Bakshi

Kiran Patel

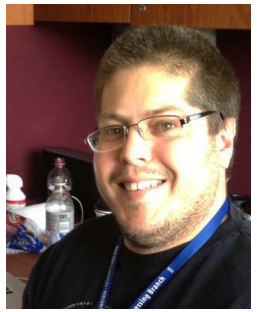
M.Kuznetsova
(**Director**)

Leila Mays
(**Deputy**)

Anna Chulaki

M. Mendoza

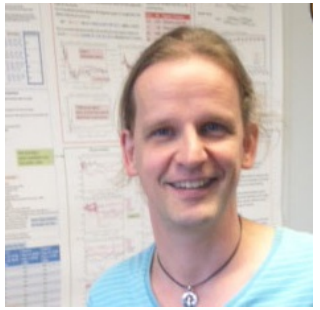
Chiu Wiegand
(Software development team lead)



R.Mullinix

A. Pembroke

J. Boblitt



L. Rastaetter

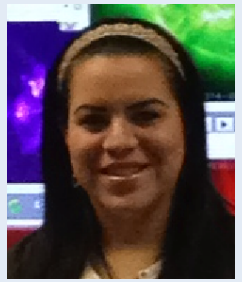
Ja Soon Shim

P. Macneice

A. Taktakishvili

B. Thompson

K. Muglach
+students



Y. Collado-Vega
(Prototyping team lead)

Yihua Zheng

NASA+NSF ~ 13 FTEs